CLEAN ENERGY AND WATER PROGRAM

DRAFT SOUTHERN BASIN MANAGEMENT PLAN

September 2015

DRAFT SOUTHERN BASIN MANAGEMENT PLAN

Yerevan 2015

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LIST OF ABBREVIATIONS

AMD	*Armenian Dram*
a.s.l.	*Above Sea Level*
AWSC	*Armenian Water Supply and Sewerage Company*
BAT	*Best Available Technology*
BMA	*Basin Management Area*
BOD	*Biological Oxygen Demand*
CIS	*Common Implementation Strategy*
CJSC	*Closed Joint-Stock Company*
COD	*Chemical Oxygen Demand*
DDT	*Dichloro Diphenyl Trichloroethane*
DSS	*Decision Support System*
EC	*European Commission*
EIMC	*Environmental Impact Monitoring Center*
EU	*European Union*
GAP	*Good Agricultural Practice*
GDP	*Gross Domestic Product*
GIS	*Geographic Information Systems*
ha	*Hectare*
HPP	*HydroPower Plant*
IWRM	*Integrated Water Resources Management*
JSC	*Joint Stock Company*
km	*kilometre*
LLC	*Limited Liability Company*
MAC	*Maximum Allowable Concentration*
mln	*Million*
mm	*Millimetre*
MNP	*Ministry of Nature Protection*
MTAES	*Ministry of Territorial Administration and Emergency Situations*
OJSC	*Open Joint-Stock Company*
PE	*Population Equivalent*
PoM	*Program of Measures*
RA	*Republic of Armenia*
RB	*River Basin*
RBM	*River Basin Management*
RBMP	*River Basin Management Plan*
SHPP	*Small Hydropower Plant*
SNCO	*State Non-Commercial Organization*
SWC	*State Water Cadastre*
USAID	*Unites States Agency for International Development*
WFD	*Water Framework Directive*
WQCI	*Water Quality Canadian Index*
WRMA	*Water Resources Management Agency*
WUA	*Water Users' Association*

CHAPTER 1: CHARACTERIZATION OF THE SOUTHERN BASIN MANAGEMENT AREA

1.1. General Description of the Southern Basin

1.1.1. Geography

The Southern Basin Management Area (BMA) is located in the south of the Republic of Armenia (RA), covering the whole territory of Syunik region (marz). It borders the Republic of Nagorno-Karabakh in the north-east and east, Islamic Republic of Iran with the Araks River in the south, Republic of Azerbaijan, Nakhichevan in the west and south-west, and Ararat BMA of Armenia in the north-west (Figure 1.1).

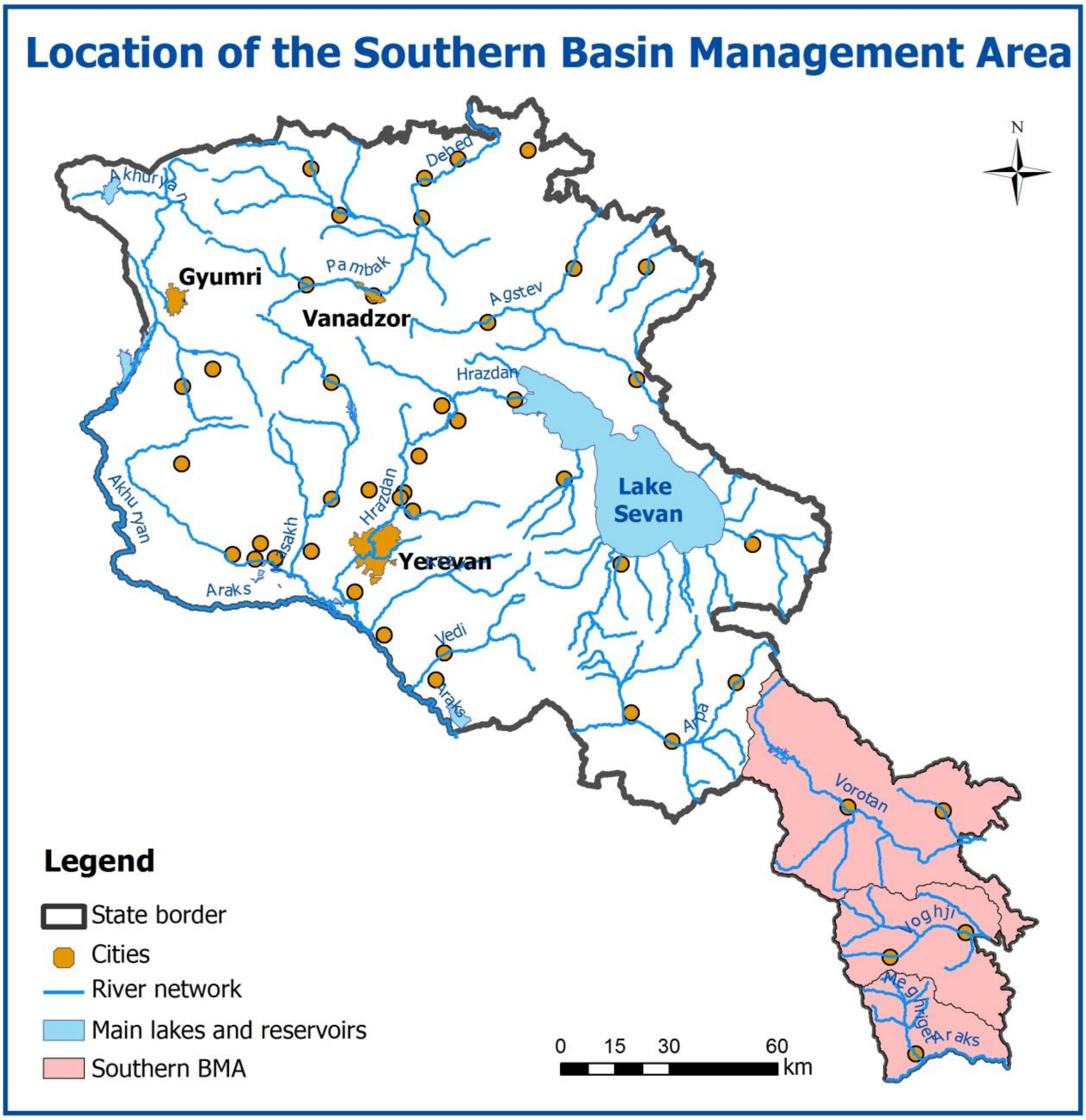


Figure 1.1: Location of the Southern BMA on the territory of the RA

Source: USAID Clean Energy and Water Program, 2014 (Coordinate system WGS, UTM Zone 38N)

The surface of the Southern BMA is 4498.17 km^2, including the Vorotan, Voghji and Meghriget River Basins. The BMA lies at a latitude of $39^0 52'$–$38^0 50'$ north and at a longitude of $45^0 42'$-$46^0 32'$ east. The total reach of the basin is 123 km from east to west and 128 km from north to south. The lowest point is at the crossroads of the Araks River and eastern border of the Republic of Armenia (374 meters above sea level (m. a.s.l.)), and the highest point is Kaputjugh peak of the Zangezur Mountain Range (3904 m a.s.l.).

1.1.2. Topography, Geology and Hydrogeology

Topography: The Southern BMA is characterized by highly complex and diverse topography, where the variations in altitude are greater than 3000 m. It combines fold, coulisse-shaped and linearly stretched mountain ranges, volcanic massifs, upland plateaus, intermountain concavities, and river valleys (Figure 1.2).

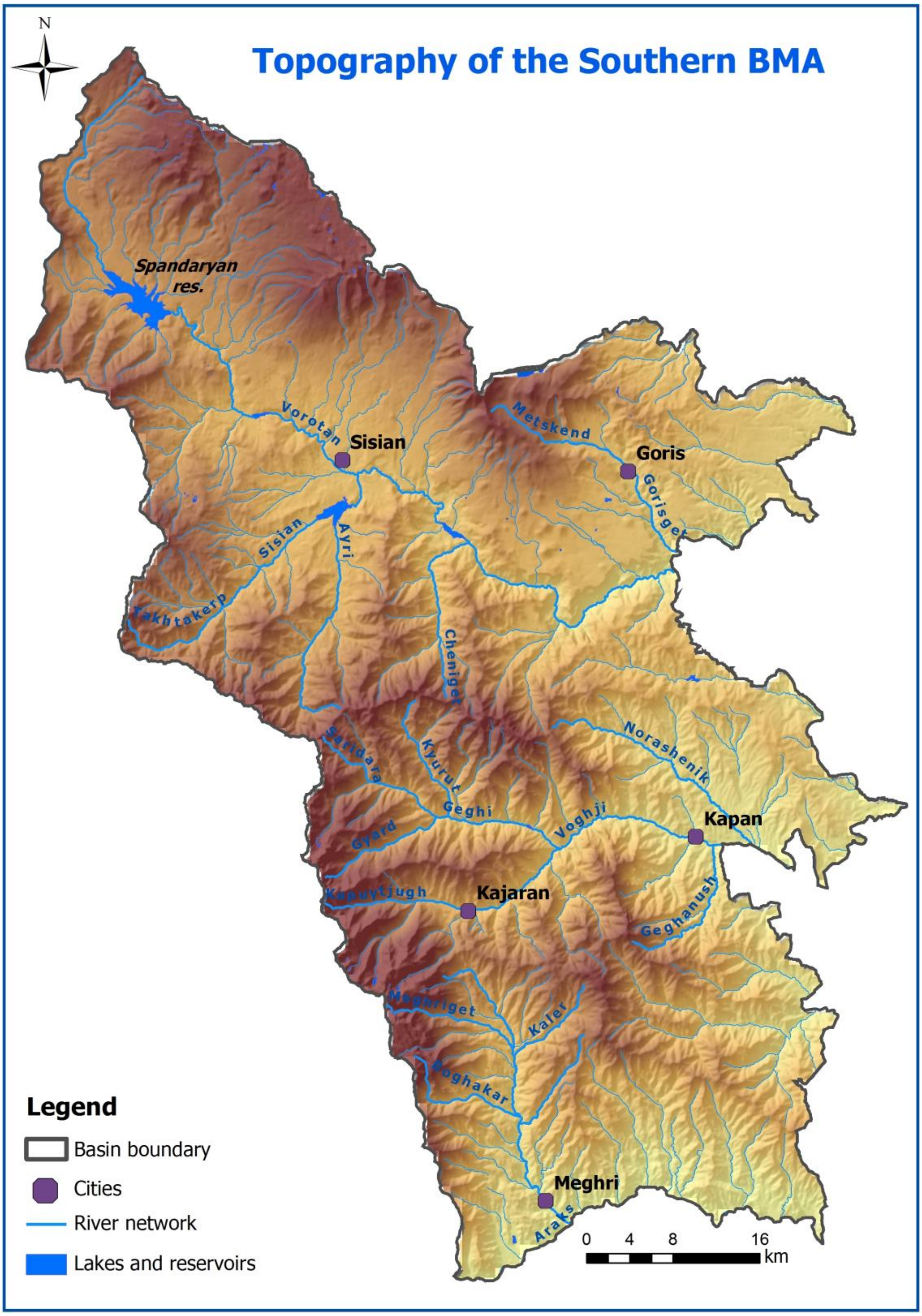


Figure 1.2: Topography of the Southern BMA

Source: RA Digital Elevation Model (NASA SRTM, coordinate system WGS, UTM Zone 38N)

Two orographic zones are distinguished in the Southern BMA: fold mountain ranges and a volcanic mountain ridges.

The Syunik Volcanic Mountain Range extends for 60 km across the northeast of the Southern BMA, with its peaks ascending over 3500 m (Tsghuk - 3581 m, Mets Ishkhanasar - 3550 m). It passes amid the Vorotan, Tartar and Hagari Rivers, extending from northwest to southeast. In the north it embraces a large hilly plateau at an altitude of 2400-2800 m, with numerous cone-shaped slaggy hills. In the south, the mountain ridge is fractured and is formed by 3200-3500 m high volcanic massifs (Tsghuk, Mets Ishkhanasar, etc.). The gradient and fractured slopes of the massifs descend into Angeghakot, Tsornasar, Goris and Tegh plateaus, comprised of an enormous lacustrine sedimentary layer. There are also other plateaus in the Southern BMA, namely Aknashat or Gorhayk, Sisian and Shamb.

The Zangezur Mountain Range is the largest orographic unit of the Southern BMA, extending for 130 km along the western and northwestern part of the basin. It starts at the juncture of the Vardenis and Arevelyan Sevan Mountain Ranges (Qeti Mountain) and stretches to the Araks River, Meghri Canyon.

The peaks of central and southern parts of the mountain range are sharp and rough, reaching altitudes of 3700-3900 m (Kaputjugh - 3904 m, Sisakapar - 3826 m, Gazana - 3856 m, Nahapet - 3506 m, and Parakan - 3826 m.a.s.l). The slopes are highly gradient (35° and more), and they are fragmented by the Voghji and Meghriget River Valleys. There are few mountain passes; the most important ones are Vorotan (2344 m) and Meghri (2583 m) that provide a passage for the interstate road between Armenia and Iran.

Subapical sections are characterized by snow-glacial topography - carrs, troughs (particularly in Kaputjugh, Geghi, Kajaran and Meghriget) and moraines, with snow heaps and firn fields preserved as part of it. The area is frequently exposed to frost weathering and erosions. There are a number of glacial lakes, including Gazana, Kaputan (Gogi), Tsakqar and Ananun. The northern part of the Zangezur Mountain Rabge is characterized by relatively lower altitudes (up to 2800 m), and “reversed” topography, which is particularly noticeable in the section between the Ayrisar and Salvard mountain peaks.

The fold Bargushat Mountain Range, located in the hillside of the Zangezur Mountain Range, extends for 42 km amid the Vorotan and Voghji River Basins. The peaks reach over 3000 m, particularly Aramazd - 3392 m, Geghaqar – 3343 m, and Tarkatar - 3277 m. The slopes of the Bargushat Mountain Range are gradient and short; they are fragmented by the Vorotan and Geghi River Valleys. The mountain Range descends south-east (near Kapan).

The topography of the Southern BMA is characterized by great slopes and fragmentation. Some parts of the Vorotan, Voghji and Meghriget River Valleys reach a depth of 700-800 m. Small karst landforms can be observed in the Vorotan Canyon near Tatev settlement, such as travertine made “Satanayi Kamurj” (Satan’s Bridge) in Cretaceous limestones. About 20% of the Southern BMA is covered with slopes of 0-15^0 that are primarily located in volcanic plateaus and intermountain concavities. The Vorotan Canyon, the hilltops of the Zangezur Mountain Range and central part of the Meghri Mountain Range have exceptionally steep slopes (35^0 and more). Slopes of 16-30° constitute about 60% of the Southern BMA.

Meghri Mountain Range, an eastern part of the Zangezur Mountain Range, extends for 59 km between the Voghji and Meghriget River Basins. The slopes are fragmented by the Meghriget and Voghji Rivers and their tributaries. The Armenia-Ira interstate highway passes along the Meghri Mountain Pass of the Meghri Mountain Range. Baghasar is the highest peak of the mountain range (3266 m).

The Khustup-Katar Massif extends for 38 km between the Voghji and Tsav River Basins. Its hilltops are peaked, and fragmented by the valleys of tributaries of the Tsav and Voghji Rivers.

Geology: The Southern BMA is distinguished by diversity of geology. Tectonic movements, which have been experienced since the Precambrian period, have led to geological developments.

The Syunik Volcanic Plateau mainly consists of late Pliocene-Eopleistocene volcanogenic formations. The highly cracked rocks allow for infiltration of precipitation and generation of a significant amount of ground water and confined groundwater, which then discharge as springs (Zor-zor, Zuigaghbyur, Katnaghbyur, Yotnaghbyur, Mukhuturyan, Shaqi, etc.).

The Zangezur Mountain Range has a diverse geological structure. It is formed by Neogene (andesite -basalt, andesite, dacite, rhyolite, obsidian, perlite, pumice sand, tuff-sandstone, and tuff-breccia), Paleogene (volcanogenic-sedimentary rocks, clay, sandstone, marlstone, conglomerate, limestone, brown coal, tuff, and tuff-breccia), and Cretaceous rocks (basalt, andesite-basalt, tuff-sandstone, limestone, clay slate and dolomite).

The Bargushat Mountain Range is formed by Paleozoic, Cretaceous and Paleogene volcanogenic-sedimentary and sedimentary rocks, which are fractured by granitoid intrusive formations. The fold structures of the mountain Range are disjointedly fragmented.

The Meghri Mountain Range is formed by granitoid intrusions, except the eastern edge where altered Paleozoic rocks extend.

There are many tectonic faults in the Southern BMA. The fault lines pass through the Vorotan River Valley, the section from Gorhayk to Ltsen, as well as Voghji, Meghriget and Nrnadzor River Valleys. A number of spring discharges are related to these faults.

Quaternary alluvial-prolluvial (boulder, gravel, detritus, and sand) and fluvial-lacustrine sediments, and sandy clay formations are common in the zone of the riverbeds in the Southern BMA.

The evolution of complex geotectonic of the Southern BMA has contributed to formation of its current topography, river network, land and vegetative covers.

Hydrogeology: Groundwater resources occur in the weathering crust of various geological rocks and deep cracks, as well as in the pores of alluvial-prolluvial formations along the riverbeds in the Southern BMA (Figure 1.3).

Hydrogeological complexes of volcanogenic-sedimentary, intrusive and sedimentary rocks, as well as fluvial-lacustrine aquifers of intermountain concavities widely occur in the Vorotan River Basin.

Slightly water-bearing volcanogenic, volcanogenic-sedimentary and intrusive rocks, water-bearing sedimentary rock complexes, and alluvial-prolluvial aquifers at narrow river valleys widely occur in the Voghji River Basin.

In the Meghriget River Basin, groundwater resources occur in the weathering crust of rock matrix, and alluvial-prolluvial sediments along riverbeds. They can also be found in tectonic fault zones, where they relate to both fresh and mineral water.

Main 4 groundwater bearing units of the Southern BMA are presented in Table 1.1 below.

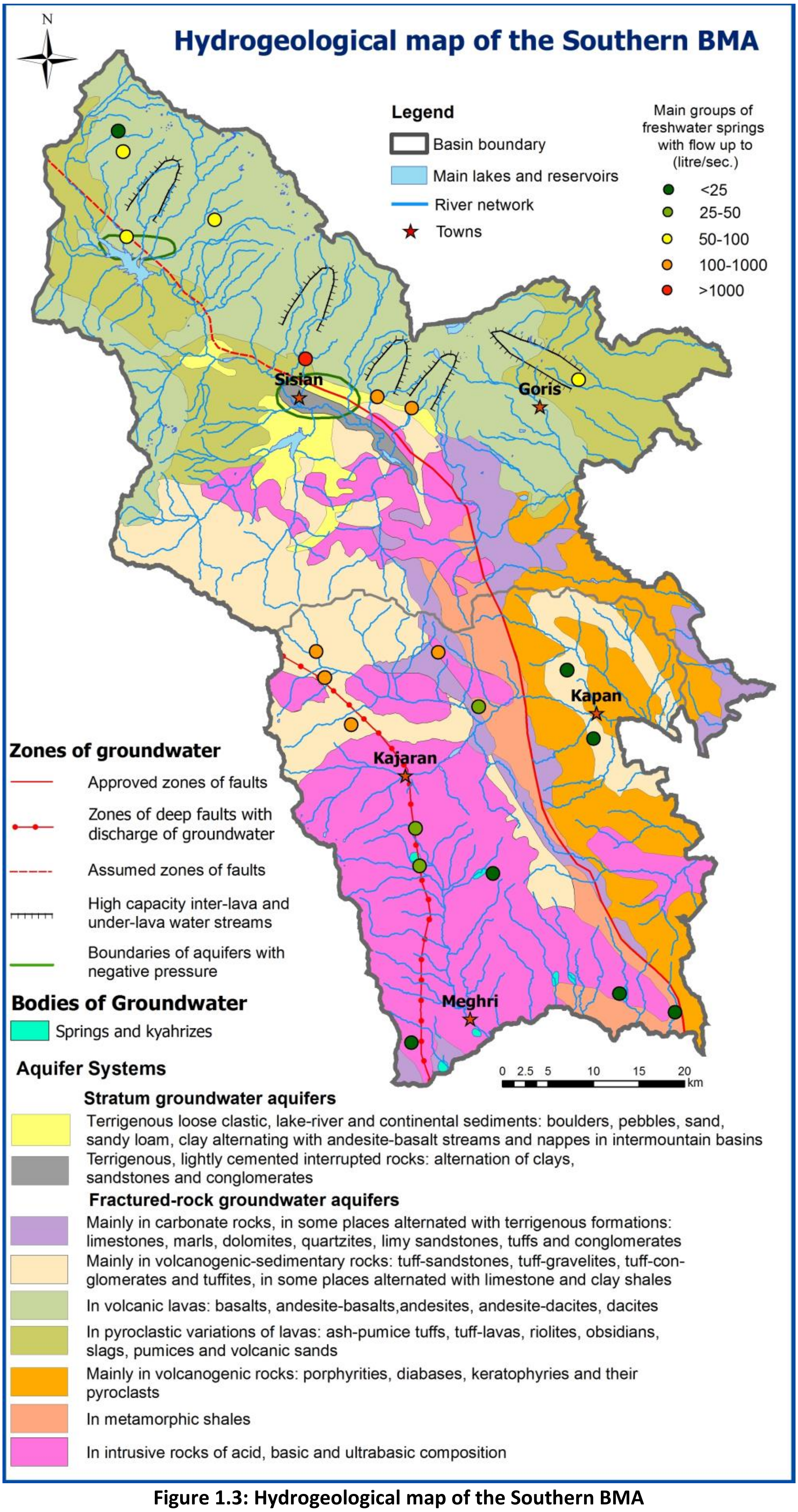


Figure 1.3: Hydrogeological map of the Southern BMA

Source: Schematic map of hydrogeology of the Republic of Armenia; edit. S Mkrtchyan, 1974 (Coordinate system WGS, UTM Zone 38N)

Table 1.1: Hydrogeological characteristics of the Southern BMA

Hydrogeological complex	Lithological composition of water-bearing rocks	Location	Relating water sources
1. Water-bearing volcanogenic rock complex	Fractured andesite-basalt, andesite, basalt	On the left bank of the upper and middle reaches of the Vorotan River Basin. Locally distributed in the Meghriget River Basin - in the vicinity of Tashtun, Lichk, Vank and Kaler settlements.	Large springs upstream and midstream the Vorotan River, including Gorhayk - 170 l/sec, Sarnakunk – 40.5 l/sec, Spandaryan - 200 l/sec, Angeghakot – 40.5 l/sec, Shaqi – 1160 l/sec, and Vaghatin 243 l/sec. Springs are characterized by a flow rate of 3-5 l/sec, and occasionally 8 l/sec in the Meghriget River Basin.
2. Low capacity water-bearing volcanogenic, volcanogenic-sedimentary and intrusive rock complex	Porphyrite, tuff-sandstone, tuff-conglomerate, tuff- diorite, granodiorite, monocyte and their other varieties	On the right bank of the middle and lower reaches of the Vorotan River Basin. Locally distributed in the Voghji and Meghriget River Basins – in the dominant part of the Voghji catchment, as well as in the vicinity of Meghri, Vardanidzor and Agarak settlements.	Springs are characterized by a highly fluctuating flow rate – up to 1 l/sec, and water temperature is in the range of 8-12^{0}C. There are around 251 springs in the Vorotan River Basin, 531 in the Voghji, and about 40 in the Meghriget.
3. Water-bearing sedimentary rock complex	Limestone, limestone sandstone, and marlstone	In the surroundings of Shinuhayr-Tatev settlements in the Vorotan River Basin; at altitudes of 2500 m and higher in the Voghji River Basin; Limited distribution in the Meghriget River Basin - the southwestern slopes of the Meghri Mountain Range.	Springs are characterized by a temporary or highly fluctuating flow rate. It is up to 1.0 l/sec in summer and 3-5 l/sec in the period of spring floods. There are 60 such springs in the Vorotan River Basin, and 43 in the Voghji.
4. Alluvial-prolluvial and fluvial-lacustrine sediment aquifers at river valleys and intermountain concavities	Boulder, gravel, sand, clay sand, sandy clay	In the middle and lower reaches of the Vorotan River and intermountain concavities; In the areas adjacent to Vardanidzor, Alvank, Shvanidzor and Nrnadzor villages; In the lower reaches of the Voghji River, as well as in the areas adjacent to Geghi, Geghanush villages and Kapan town in the Voghji River Basin.	Groundwater recharge from surface flows and drainage water from rock matrix and aquifers lying under riverbeds – Sisian, Tolors, Vorotan, etc. Springs are characterized by a flow rate of 1.5-5 l/sec and higher.

Source: Hydrogeological Monitoring Center SNCO under the RA MNP, 2013

1.1.3. Climate

The Southern BMA is distinguished by diverse climate, which is mainly due to the highly fragmented topography and variation in altitudes. The area is influenced from east to west movement of air masses and has characteristics of continental climate. When intrusion of humid air masses occurs, they highly transform and dry in the process of overcoming the Zangezur Mountain Range.

There are 7 climatic zones in the Southern BMA (Figure 1.4).

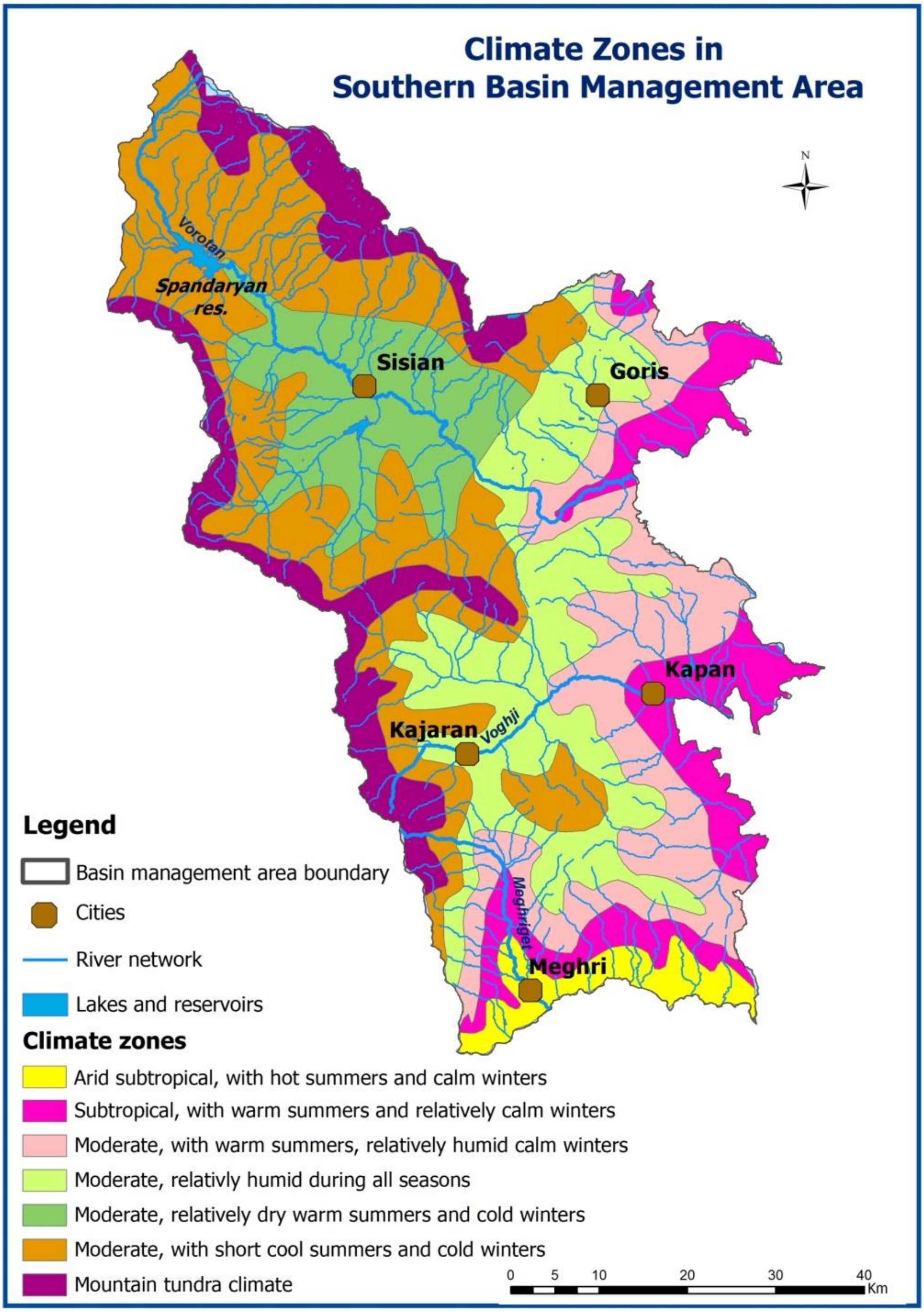


Figure 1.4: Climatic zones of the Southern BMA

Source: National Atlas of Armenia, Volume A, 2007 (Coordinate system WGS, UTM Zone 38N)

The description of climatic conditions in the Southern BMA is given based on the data provided by the Armenian State Hydrometeorological and Monitoring Service SNCO under the RA Ministry of Territorial Administration and Emergency Situations (MTAES).

Meteorological observations were made at 38 meteorological stations and observations posts in the Southern BMA. There were 6 operational observation posts as of January 2014.

Thermal conditions normally decrease in the Southern BMA as altitude increases. Multiyear annual average air temperature is in the range of 14.2-2.7°C (Table 1.2). The absolute minimum air temperature is observed to be -34.4°C (Vorotan Pass), and absolute maximum temperature - +43.4°C (Meghri). Temperature inversion is observed in Sisian and Goris that are located in intermountain concavities.

Table 1.2: Annual and monthly average air temperatures in the Southern BMA, 1961-2011, °C

Meteorological station	*Absolute altitude (m)*	*Month*												*Year*
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Goris	1398	-0.5	0.1	3.2	8.5	12.6	16.3	19.1	18.5	14.7	9.9	5.5	1.9	**9.1**
Sisian	1615	-4.3	-3.1	1.4	7.0	11.4	15.3	18.2	17.8	14.1	8.6	2.9	-1.7	**7.3**
Vorotan Pass	2387	-8.7	-7.8	-4.3	1.3	6.4	10.5	13.3	13.4	10.7	5.3	-0.9	-6.0	**2.8**
Kajaran	1980	-3.4	-3.0	0.5	5.7	10.2	14.2	17.1	16.6	13.3	8.2	3.2	-1.0	**6.8**
Kapan	704	0.8	2.4	6.3	12.3	16.1	20.4	23.7	23.1	19.0	13.0	7.5	2.9	**12.3**
Meghri	627	1.7	3.8	8.7	14.3	18.9	23.4	26.6	26.0	21.6	15.4	9.5	4.7	**14.5**

Source: Armenian State Hydrometeorological and Monitoring Service SNCO, RA MTAES

The annual distribution of precipitation is highly uneven in the Southern BMA. The amounts of precipitation by altitude are in the range of 250-900 mm (Table 1.3). Most precipitation occurs in the period of March-June.

Table 1.3: Intra-annual distribution of atmospheric precipitation in the Southern BMA, 1961-2011, mm

Meteorological station	*Absolute altitude (m)*	*Month*												*Year*
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Goris	1398	31	42	71	91	111	91	49	46	62	68	47	30	**740**
Sisian	1615	16	24	36	55	69	50	26	16	22	34	25	17	**391**
Vorotan Pass	2387	46	50	62	88	93	68	47	31	28	58	46	47	**675**
Kajaran	1980	44	51	74	84	85	49	23	21	31	52	49	41	**605**
Kapan	704	25	31	59	75	94	66	31	28	41	49	40	25	**565**
Meghri	627	14	17	32	45	49	28	11	8	14	25	23	14	**281**

Source: Armenian State Hydrometeorological and Monitoring Service SNCO, RA MTAES

Rainfall generally increases by altitude in the basin. Reduction of rainfall is observed only in the section from the Vorotan River Valley to Sisian.

The average annual relative humidity is 50-60% in the Southern BMA, and less than 30% at low altitudes (up to 1000 m). Frost-free days vary by altitude – annually from 260 (at the altitude of 600 m) to 50 days (higher than 3000 m). The annual average relative humidity is 60-80% (over 2600 m), and at lower altitudes - up to 30% (up to 1000 m).

Most clear days are observed in the Sisian region of the Southern BMA, resulting in a high radiation balance - 60-62 kcal/cm^2. The longest multiyear annual average sunshine period is also observed in Sisian - 2660 hours.

Permanent snow cover starts at altitudes of 1200 m.a.s.l. and it lasts for 35-165 days. The snow depth is 15-180 cm. It lasts 1-1.5 months at altitudes of up to 1500 m, and 6.5-7 months at altitudes of 3000 m and higher. The depth of snow cover is 15-20 cm at altitudes of 1300-1500 m and 120-180 cm at altitudes of 3000 m and higher (from place to place a 300 cm thick snow cover is formed, due to winds occurring in concavities).

The **wind regime,** including direction and velocity, mainly depends upon topography; mountain-valley breezes are observed on clear days. The annual average wind velocity reaches 1.3-4.2 m/sec, and the maximum velocity is 23 m/sec in the Southern BMA. Strong winds are observed in all mountain passes, particularly in Sisian Mountain Pass where the annual average velocity reaches 7.7 m/sec, the highest value for Armenia.

Evaporation drops to 482-220 mm as altitude increases in the Southern BMA (Table 1.4). The highest value of evaporation, 500-480 mm. is observed at altitudes up to 800 m (486 mm is observed in Meghri meteorological station) (Table 1.5).

Table 1.4: Cumulative evaporation in the Southern BMA, according to altitude zones

Altitude zones, m	*Cumulative evaporation, mm*
Up to 1000	482
1000-1500	438
1500-2000	382
2000-2500	328
2500-3000	270
3000 and higher	220

Source: Armenian State Hydrometeorological and Monitoring Service SNCO, RA MTAES

Table 1.5: Estimated data on cumulative evaporation in the Southern BMA, 1961-2011, mm

Meteorological station	*Absolute altitude (m)*	*Month*												*Year*
		I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	
Goris	1398	16	23	32	37	46	54	51	53	49	44	32	17	**454**
Sisian	1615	11	16	24	29	45	51	48	46	40	34	25	13	**382**
Vorotan Pass	2387	6	7	13	22	36	45	38	36	30	27	15	6	**281**
Kajaran	1980	9	11	18	27	42	48	51	55	36	24	18	11	**350**
Kapan	704	14	16	32	44	55	59	61	65	52	45	33	18	**494**
Meghri	627	17	21	34	48	53	60	62	59	44	38	27	23	**486**

Source: Armenian State Hydrometeorological and Monitoring Service" SNCO, RA MTAES

1.1.4. Landscapes (types of ecosystems)

There are 8 vertical landscape zones throughout the Southern BMA: submontane semidesert, low and middle mountain beyond forest, low and middle mountain forest, middle mountain steppe, middle mountain meadow steppe, high mountain subalpine, high mountain alpine and high mountain sub-nival (Figure 1.5).

The **submontane semidesert zone** covers the lower reaches of the Karchevan, Meghriget, Astghadzor, Shvanidzor and Nrnadzor Rivers. Arid subtropical climate is typical for this zone, with a small amount of precipitation (250-300 mm), very dry air, and intensive evaporation. The aridity index is 5. Winters are mild, with little snow. Atmospheric precipitation occurs as rainfall. The number of frost-free days is 250. The average air temperature is 25°C in July and 0.9°C in January. This zone is poor in river waters and springs. Due to the highly rugged topography and physical weathering, brown skeletal rocky soils predominate here. Soils are shallow and do not contain organic substances.

Having been affected by Iranian desert landscape, this zone is poor in vegetation. There are phryganoid plants, such as phrygana, tragacanth and tomillares. The submontane semidesert zone is rich in reptile species, including Macrovipera lebetina, Armenian Viper (*Montivipera raddei*), Schneider's skink (*Eumeces schneideri*), cat snake (*Telescopus fallax*), Transcaucasian rat snake (*Elaphe hohenackeri*), dice snake (*Natrix tessellata*), and grass snake (*Natrix natrix*). Badger is the typical mammal in this zone. Other mammals include jackal (*Canis aureus*), fox (*Vulpes*) and striped hyena (*Hyaena hyaena*).

The **low and middle mountain after forest** zone extends at altitudes of up to 1000 m. The quantity of precipitation is 300-400 mm, and evaporation amounts to 400-450 mm, thus creating an irrigation demand here. This zone is poor in springs and ground waters. Skeletal brown and chestnut soils prevail here. The vegetation predominantly consists of thin xerophilous bushes (Christ's thorn (*Paliurus spina-christi*) and sibljak). Forest parks are common on the northward slopes (Arax oak (*Q. araxina*)). The grass cover mainly consists of cereals. Nettle tree (*Celtis*) predominates among tree species and Christ's thorn (*Paliurus spina-christi*) among bushes.

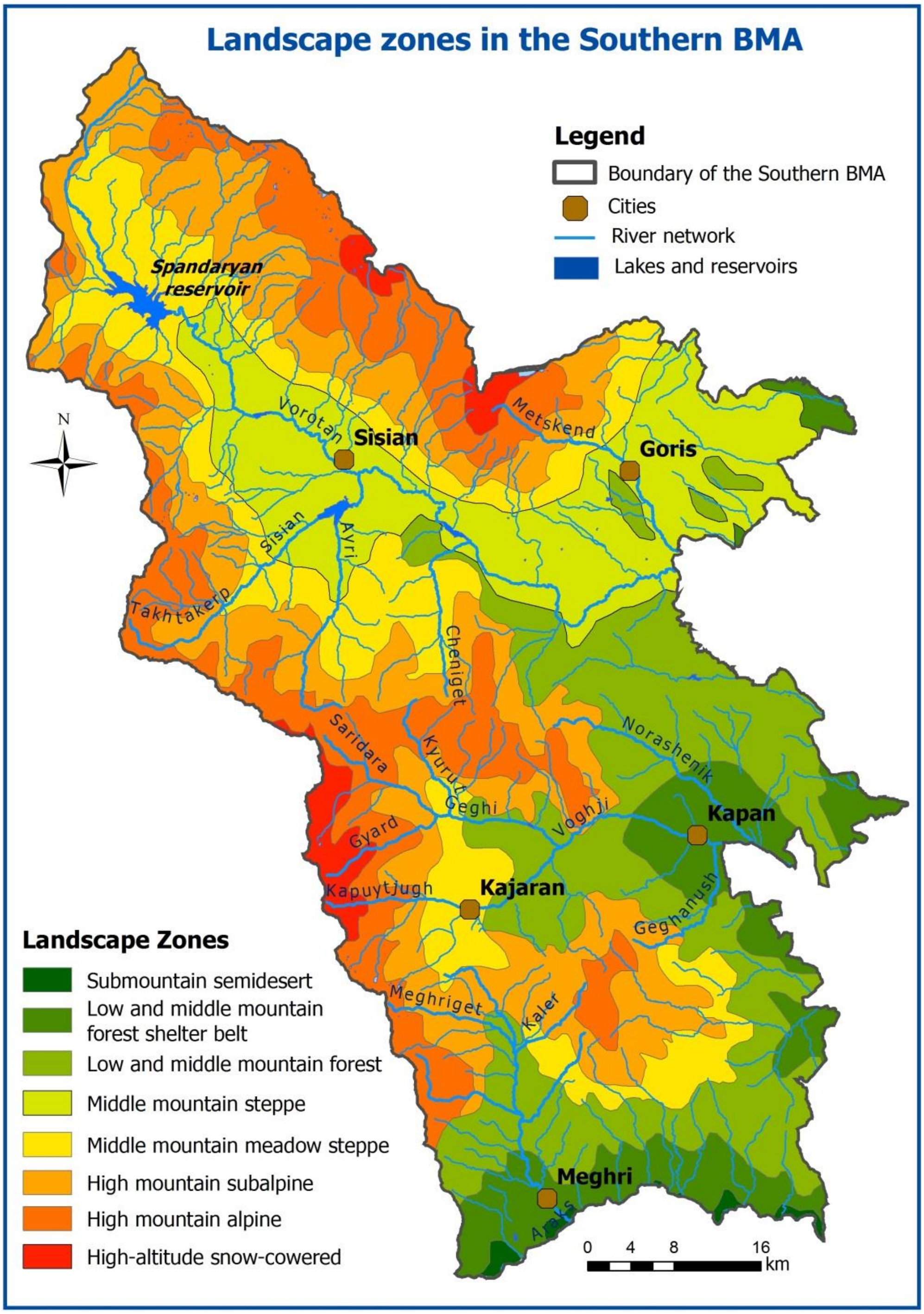


Figure 1.5: Landscape zones in the Southern BMA

Source: National Atlas of Armenia", Volume A, 2007 (Coordinate system WGS, UTM Zone 38N)

The common bird species include Persian robin, Eastern rock-nuthatch (*Sitta tephronota*), and Syrian woodpecker (*Dendrocopos syriacus*). This zone is inhabited by mammals, such as wild boar (*Sus scrofa*), predators, such as golden jackal and bear commonly observed in river valleys, and wild goat (*Capra aegagrus*), mouflon (*Ovis aries orientalis*) and striped hyena (*Hyaena hyaena*) in rocky areas.

The most common reptiles include blunt-nosed viper (*Macrovipera lebetina*), dice snake (*Natrix tessellata*), and grass snake (*Natrix natrix*), European legless lizard (*Pseudopus apodus*), and Armenian mountain steppe viper. Twin-striped skink (*Ablepharus bivittatus*), cat snake, and Transcaucasian rat snake (*Elaphe hohenackeri*) can be observed in the lower section of the Tsav River Basin. The common rodents include long-tailed white-toothed shrew (*Crocidurinae*), small horseshoe bat (*Rhinolophidae*), and Persian jird (*Meriones persicus*). There are 5 reptile species listed in the RA Red Book, namely Armenian tortoise (*Testudo graeca armeniaca*), Schneider's skink (*Eumeces schneideri*), cat snake, Transcaucasian rat snake (*Elaphe hohenackeri*), and Vipera raddei (*Armenian vipera*).

The **low and middle mountain forest zone** embraces river valleys and the areas among tributaries in the Southern BMA, lying at altitudes of up to 2400 m. Moderately cold and semi-humid climatic conditions are typical of this zone. Annual precipitation is 500-750 mm. Average annual relative air humidity is 70-80%, and the number of frost-free days - 160-280. The average air temperature is in the range of (-2)-(-4)° in January, and 16-18° in July.

Relict maple and hornbeam forests are preserved in the Shurnukh River Basin. Hornbeam and oak forests are common on the northern slopes, at altitudes of 1200-1300 m, and Georgian oak on the southern slopes. Forests mainly consist of hornbeam and oak (Georgian and Oriental) species; ash, maple, walnut, and wild pear can also be observed. Hawthorns (*Crataegus*), medlars (*Mespilus germanica*), plum trees and apple trees are observed in the oak woods extending on drier slopes. The southern slopes of the mountain forest zone are mainly covered with thin xerophilous forests and shibliak bushes.

Thick forests are common on the northern slopes of the Tsav River Basin, at altitudes of 1800-2000 m. Virgin oak wood is preserved in the area of Mtnadzor. The upper forest area is thin (at the altitude of up to 2400 m), comprising of Caucasian oaks (*Quercus macranthera*), and the lower one is thick with dense foliage.

The soil cover is thin; carbonate and lime-free brown soils, with humus composition of 3.6%, are prevalent here. The flora mainly consists of bushes (briar) and tree-bushes (oriental hornbeam, Christ's thorn, almond tree, cherry tree, mountain ash, hornbeam). Forests contain many boscages though oak and hornbeam are the prevalent tree species. The zone is also covered with tragacanth plants and cereals.

The forest zone is rich in fauna. The mammals include buck, boar, bear, wildcat (*Felis silvestris*), Indian porcupine (*Hystrix indica*), wolf, fox, gray rabbit, long-eared hedgehog (*Hemiechinus auritus*), and occasionally wild goat (*Capra aegagrus*) and leopard. The common bird species include Caspian snowcock (*Tetraogallus caspius*), blue-cheeked bee-eater (*Merops persicus*), black woodpecker (*Dryocopus martius*), golden eagle (*Aquila chrysaetos*), griffon vulture (*Gyps fulvus*), partridge, whitethroat, Caucasian grouse (*Tetrao mlokosiewiczi*), tit, bustard, blue rock thrush (*Monticola solitarius*) and redstart. Forest owlet (*Athene blewitti*), eagle-owl, buzzard, black grouse (*Tetrao tetrix*) and hawk are also widespread.

There are few reptile species in the forest zone; only the legless snake lizard can be observed and the tree-frog from amphibians.

There are many insects in the forest, such as green dragonflies, several species of beetles, and shrews. The rodents include Major's pine vole (*Microtus majori*), Persian squirrel (*Sciurus anomalus*) and dormouse. Weasels, martens, badgers, wood mice (Apodemus *sylvaticus*) and moles are also observed in this zone.

The **middle mountain steppe zone** embraces altitudes of 1000-2300 m. The zone is characterized by temperate semiarid climate. The annual number of frost-free days varies by altitude, ranging from 120 to 160 days. Average annual precipitation is 500-650 mm, and average annual relative air humidity - 50-60%. Mountain steppes are covered with brown and gray-shade mountain soils, which are cloddy, with 2-3.5% humus content. The vegetation is xerophilous, consisting of couch-grass, mat grass and fescue grass. Relatively high-power black earth, with 6.5% humus content, appears on the northward slopes of the mountain steppe zone. Cereal herbs and feather grass (mat grass) are most common here. Alluvial, marshy and marshy-meadow soils (with a high content of organic substances) are common in concavities. These soils are covered with dense meadow vegetation.

The mountain steppe is the main agricultural zone in the Southern BMA.

The **middle mountain meadow steppe zone** covers altitudes of up to 2300 m. Average annual precipitation is 550-750 mm, and average annual relative air humidity - 60-70%. Mountain meadow steppes are covered with dark brown and black-gray mountain soils, with 2-3% humus content. From place to place black earth appears on the northward slopes, with 5-6% humus content. Cereals consisting of motley grass (forbs) and feather grass predominate here. Couch-grass vegetation is most common in the mountain meadow steppe zone. Meadow steppe soils are characteristic of this zone, with chestnut and black earth-like subtypes. Alluvial sedimentary and marshy-meadow soils, with prairie vegetation, randomly occur in the ravines along the middle and upper reaches of the rivers.

Mountain meadow steppes are rich in birds, rodents and reptiles. The bird species include hen-harrier, partridge, wild duck, etc. The rodents include blind mountain mouse and Turkish hamster (*Mesocricetus brandti*). Hares and wild boars are also widespread in this zone.

The **high mountain subalpine** zone lies at altitudes of 2300-2500 m. The temperate cold climate is typical of this zone. It is a transition from steppe to alpine zones and occupies small areas.

Wet and black earth-type subalpine mountain-meadow soils commonly occur in the upper parts of this zone. The vegetation predominantly consists of Bromus and fescue species. The lower part of the zone is covered with meadow steppe soils, with chestnut and black earth subtypes.

The **high mountain alpine zone** extends at altitudes of 2300-3300 m. Cold humid mountainous climate is typical of this zone. The amount of precipitation is larger than evaporation, 700-800 mm (in some places - 900 mm) and 250-300 mm, respectively. Excess moisture generates surface flow, which in its turn causes spatial and linear erosion. The average air temperature is -10°C in January and 10-12°C in July. The length of the frost-free period in a year is 50-80 days. Frosty weathering processes prevail in this zone, causing formation of stone deposits.

The zone is widely covered with black earth-type, and sometimes turf and humus rich mountain steppe soils. Alpine meadows are typical here, with a vegetation cover consisting of cereals, forbs and carices. Fescue species can also be observed on steep slopes.

Small rodents, particularly field mice inhabit the high-mountain subalpine and alpine zones. Bezoar goats and wild sheep can also be observed in the uplands of the Zangezur Mountain Range. There are also many bird species here, such as Caspian snowcock, whitethroat, etc.

The **high-mountain sub-nival zone** extends over the hilltops of mountain ranges – at altitudes of over 3200-3500 m. Despite of the intensity of solar radiation and long-lasting sunshine, the solar radiation balance is mostly negative during the year. The climate is severe and cold, with winters lasting 6 months and longer. Annual rainfall is over 800-900 mm. These provide favorable conditions for accumulation of moisture (in form of snow, firn, or ice). Average snow cover is 2 m deep, and annual average days with snow cover amount to 270. Snow cover is preserved all year long in form of snow, firn or ice in specific landforms of periapical and apical areas. Short and cold summers do not provide adequate thermal conditions for the growth of a vegetative cover. Land cover does not form here as only the initial stage of soil formation occurs.

Frosty weathering processes highly occur here, and stone deposits are widespread. As a result, soil cover is thin; only the initial stage of soil formation occurs.

Chionophilous and chomophyte (adapted to rock cracks and stones) vegetation is typical of this zone. The common plant species include Senecio, Pyrethrum, etc.

Agricultural lands do not occupy a large area in this zone; only the lower parts of the zone are used as pastures in summer.

1.1.5. Specially Protected Natural Areas

There were 1 reserve, 1 national park and 6 sanctuaries in the Southern BMA as of January 2014 (Figure 1.6). These areas constitute about 14.3% of the total area of the Southern BMA.

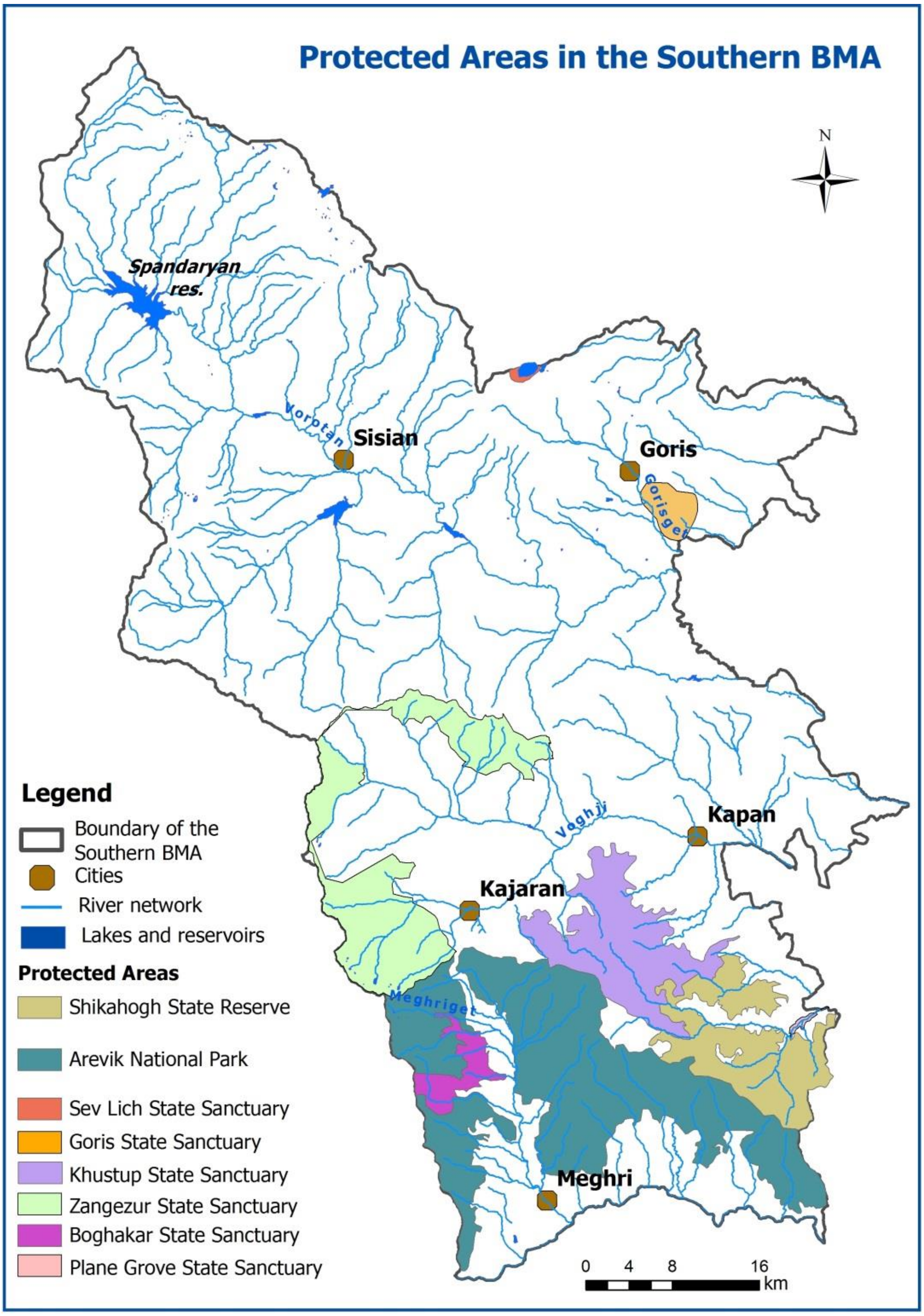


Figure 1.6: Specially protected areas of the Southern BMA

Source: Syunik marz Administration, 2013 (Coordinate system WGS, UTM Zone 38N)

State Reserves

Shikahogh State Reserve was established as a sanctuary based on the Armenian Soviet Socialist Republic (ASSR) Board of Ministers' Decree No. P-341, dated 13 September 1958, and obtained the status of a reserve based on ASSR Board of Ministers' Decree No. 728, dated 27 October 1975. The reserve occupies 12137 hectares of area and covers the Tsav and Shikahogh River Basins, northern slopes of the Meghri Mountain Range, at altitudes of 700-2400 m. The main subjects of protection include the broadleaf forests (oak and hornbeam), unique plant communities (yew, oriental plane, and oriental beech), their flora and fauna (porcupine, leopard, mouflon, and wild goat).

National Parks

Arevik National Park was established based on the RA Government Decree N 1209-N, dated 15 October 2009. It embraces the upper and middle reaches of the Meghriget, Nrnadzor and Shvanidzor Rivers, the areas of Lichk (11914 ha) and Shvanidzor (14512 ha) state forests at Meghri forestry, including the area of Boghakar (2728 ha) Sanctuary (26426 ha in total), and state-owned watershed areas of the Shvanidzor and Nyuvadi River Valleys (7975.8 ha) located beyond the administrative boundaries of the communities in Syunik Marz (34401.8 ha in total).

State Sanctuaries

Sev Lich (Lake Sev) State Sanctuary was established according to the RA Government Decree N-975, dated 12 October 2001. It is located at the foothill (around the crater) of Mets Ishkhanasar Mountain, at the altitude of 2658 m, and occupies 185 hectares of area. The purpose of creation of this sanctuary was to preserve the unique mountainous volcanic basin and its adjacent natural areas, with 102 species of vascular plants, and alpine flora and fauna.

Goris State Sanctuary was founded in 1972 and encompasses 1850 hectares of land. It is located in the basin of the Vararakn River, tributary of the Vorotan River, at altitudes of 1400-2800 m above sea level. It conserves forest landscapes and their typical fauna.

Zangezur Sanctuary was founded based on the RA Government Decree No. 1187-N, dated 15 October 2009, and operates under the Shikahogh State Reserve SNCO of the RA MNP. The sanctuary covers 17368.77 hectares of area. It extends over the southern slopes of the Bargushat Mountain Range and eastern slopes of the Zangezur Mountain Range, at altitudes of 2600-3904 m.a.s.l. The aim of this sanctuary is to ensure normal development, conservation, protection, restoration, and reproduction of the landscape and biological diversity of subalpine meadow and meadow-steppe natural ecosystems, unique natural monuments, and natural resources, as well as sustainable use of natural and recreational resources.

Sosu Purak/ Plane Grove Sanctuary was founded based on ASSR Board of Ministers' Decree No. 341, dated 13 September 1958, and operates under the Shikahogh State Reserve SNCO of the RA MNP. The sanctuary is located in the Tsav River Basin, at altitudes of 700-750 m, and occupies 60 hectares of area.

Khustup Sanctuary occupies 6946.74 hectares of area and includes the high mountainous section of the Khustup Massif - the southwestern extension of the Meghri Mountain Range.

Boghakar Sanctuary was founded based on ASSR Board of Ministers' Decree No. 533, dated 27 October 1989. It is located in the **Arevik National Park** and occupies 2728 hectares of area.

Based on the RA Government Decree No. 1465-N, dated 19 December 2013, the Arevik National Park, Shikahogh State Reserve, Sosu Purak, Zangezur, Boghakar and Sev Lich State Sanctuaries, as well as Khustup state reserve which is in the process of establishment (the southwestern part of the Meghri Mountain Range and the upper forest zone on the slopes of the Khustup Massif, with total area of 6946.74 hectares), were reunited, thereby laying the foundation of the Zangezur Biosphere Complex SNCO of the RA MNP.

Natural Monuments

There are over 100 natural monuments in the Southern BMA, of which “Shaqi jrvezh” (Shaqi waterfall) and “Satanayi kamurj” (Satan’s bridge) are of particular significance.

“Shaqi jrvezh” (Shaqi waterfall) (18 m high) is situated in the Vorotan Canyon, 3 km northwest of Sisian, on Shake left-wing tributary of the Vorotan River. Shake is the highest and most beautiful waterfall in Armenia. It constantly attracts visitors and remains in the center of tourists’ attention.

“Satanayi kamurj” (Satan’s bridge) is located on the Vorotan River, within Tatev-Halidzor settlements. It is considered a natural wonder in Armenia. The bridge has a width of about 150 m and a length of 200 m. It has a flat surface made up of limestone and travertine. Hot mineral springs bubble out of its various holes. The two slopes of the gorge are also comprised of travertine and descend to the edge of the bridge from both sides of yellowish and reddish scars, with barriers of 250-300 m altitude. These two scars are so close to each other that they form a 180-200 m wide narrow passage. The bridge is approximately 100 m above the river level. Travertine poles and large stalactites hang over the river. They are yellow but tend to turn green at the bottom. These stalactites form when calcium and other salts dissolve in the mineral water flowing into the surrounding scars and land of the bridge.

There are mineral springs in the surroundings of Satan’s Bridge that generate 500-600 liters of water daily. The water temperature is 25C°.

There are many other geological, hydrogeological, hydrographic, natural, historic, and biological monuments in the Southern BMA.

1.1.6. Water related Natural Disasters

The description of water related disasters in the Southern BMA was given based on data provided by the Armenian State Hydrometeorological and Monitoring Service SNCO under the RA MTAES

Landslides: Landslides are mainly common in the upper and middle reaches of the Gorisget, Sisian, Ayriget, Shaghat, Voghji, Geghi, Norashenik and Artsvanik Rivers, as well as in the areas of Karahunj, Balak, Shaghat, Kapan, Norashenik, Khalaj, Lichk, Tashtun, Vardanidzor, Vahravar, Tkhkut and Meghri communities. The presence of ground water is the primary cause of landslides.

The southern part of the Kapan town is a relatively active landslide zone. It intensified in 1994 and 1996, causing great damages and deaths. The landslide next to Angeghakot village in the Vorotan River Basin is considered to be active and threatens to obstruct certain parts of the Vorotan riverbed.

Mudflows: Mudflows are more active among the natural disasters in the Southern BMA. According to the data from the Armenian State Hydrometeorological and Monitoring Service SNCO under the RA MTAES, the tributaries in middle and lower reaches of the Vorotan River (left-bank tributary Gorisget, right-bank tributaries Sisian, Ashotavan, Loradzor and Tatev), middle and lower reaches of the Voghji and Meghriget Rivers, as well as left-bank tributaries Kavart, Barabatum, Norashenik, and Artsvanik and right-bank tributaries Geghanush and Vachagan of the Voghji River are prone to mudflows. Mudflows are mainly of pebble and pebble macadam composition.

The frequency of mudflows is every 3-5 years for the Shaghat, Sisian, Ayriget, Voghji and Norashenik Rivers that are prone to mudflows, as well as small tributaries of the Araks River in the Meghriget River Basin. The frequency of mudflows is every 1-3 years in the Gorisget and tributaries flowing into the Hagari in the northeastern part of Goris region, Kavart and Norashenik tributaries of the Voghji River, Meghriget and Karchevan Rivers, and every 5-10 years in the rest of the mudflow-prone rivers.

Figure 1.7 illustrates the areas prone to landslides and mudflows.

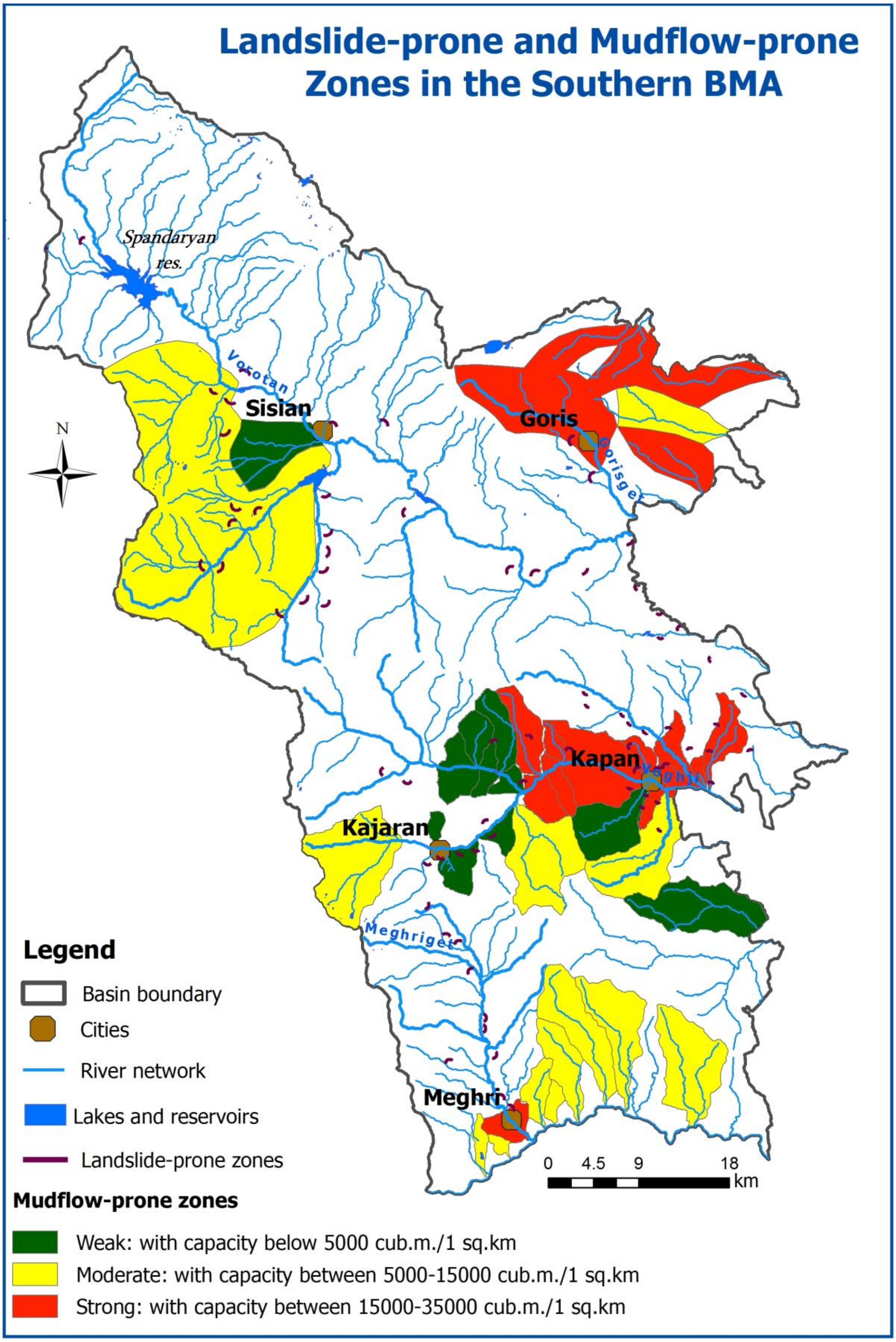


Figure 1.7: Areas prone to landslides and mudflows in the Southern BMA

Source: Armenian State Hydrometeorological and Monitoring Service SNCO under the RA MTAES, 2012 (Coordinate system WGS, UTM Zone 38N)

Table 1.6 provides information on extensive mudflows recorded in the Southern BMA.

Table 1.6: Extensive mudflows recorded in the Southern BMA

River	*Location*	*Date of occurrence*	*Driver*	*Water discharge, m^3/sec*
Gorisget	Goris town, Karahunj village	04.08.1957	rain	38.4
Urut	River mouth	11.07.1965	rain	18.5
Vorotan	Vorotan village	14.05.1967	rain, snowmelt	228
Sisian	Arevis village	13.05.1967	rain, snowmelt	27.3
Ayriget	Torunik village	13.05.1967	rain, snowmelt	16.5
Gorisget	Goris town	18.06.1967	rain	46.8
Sisian	28 km downstream the Arevis village	18.04.1968	rain, snowmelt	49.7
Ayriget	Torunik village	18.04.1968	rain, snowmelt	18.9
Gorisget	Near Goris HPP	29.05.1972	rain, snowmelt	19.5
Khoznavar	1 km downstream the Khoznavar village	12.06.1972	rain	16.3
Gorisget	300 m upstream the bridge in Goris town	23.07.1987	rain	22.8
Gorisget	Goris town	25.05.1997	rain, snowmelt	32.7
Sisian	Ashotavan, Hatsavan, Tasik villages	28.04.1997	rain, snowmelt	60
Gorisget	Vernishen, Akner, Karahunj villages and Goris town	22.06.1997	rain	25.6
Gorisget	Goris town	07.06.2013	rain	26.8
Voghji	Kapan town	28.08.1972	rain, snowmelt	270
Kavart	Kapan town	29.05.1972	rain	73.0
Vachagan	Kapan town	20.07.1960	rain	47.9
Norashenik	Achanan and Syunik village	21.07.1960	rain	65.8
Meghriget	Meghri town	12.06.1956	rain, snowmelt	87.5
Meghriegt	Meghri town	18.08.1972	rain	44.7
Meghriget	Meghri town	01.05-1969	rain, snowmelt	75.7
Astazurget	Shvanidzor	14.05.1967	rain	20.2

Source: Armenian State Hydrometeorological and Monitoring Service SNCO under the RA MTAES

Erosion: Erosions are mainly anthropogenic in the Southern BMA. Anthropogenic erosions due to operation of mines are observed in the surroundings of Kajaran town, Ajabaj village in the Geghi River Basin, Achanan village in the Kavart and Norashenik River Basins, as well as Kuris, Agarak, Vardanidzor and Tkhkut settlements in the Karchevan River Basin. During the recent years, primarily slopes have been exposed to erosion in the above mentioned areas.

Erosions caused by livestock breeding, irregular opening of earth roads, and use of fallow agricultural lands are observed in the section from Sisian town to Tolors reservoir in Sisian region, as well as in Sisian, Ayriget, Gorisget, Loradzor and Shaghat river basins. The slopes lying in the south and east of Dastakert settlement, and the ones surrounding Shenatagh village are exposed to erosion due to the density of earth roads. Slope erosion has recently intensified due to operation of the sand mine in the surrounding of Sisian airport.

Erosions are observed on the slopes close to almost all settlements, due to the density of earth roads used for livestock.

Bank erosion is observed in the middle reaches of rivers and riverbeds in the Southern BMA.

Snow slides: Snow slides are observed upstream the Meghriget, Voghji and Geghi rivers in the Southern BMA, at altitudes of 1400-3400 m. Over 80 snow slides occurred in these areas during 1974-2013, at an average volume of 80-100 m^3. The most damaging snow slide was observed in the Vorotan River Basin in 1988, at a volume of 96 thousand m^3.

1.1.7. Social and Economic Setting

Data presented in this section are based on the materials received from the National Statistical Service and the Syunik region (marz) Administration.

Demographics: there were 141000 people residing in the Southern BMA as of January, 2014, (*de-jure* population), including 49.2% male and 50.8% female.

There are 109 communities in the Southern BMA, 7 of which are urban and 102 rural. The urban population makes up the majority of the population, 67.2%. The nationality of the population is almost uniform in composition, foreigners make up about 0.26% of the entire population.

Although there has been a positive natural growth in population of the Southern BMA in 2013, the permanent population decreased due to migration (Table 1.7).

Table 1.7: Southern BMA population, 2010-2013, person

Population	*2010*	*2011*	*2012*	*2013*
Permanent population	141771	141747	141645	141001
Urban	95170	95196	95215	94732
Rural	46601	46551	46430	46269
Natural growth	239	236	234	212

Source: RA National Statistical Service, 2014

The age distribution and life expectancy: As of January 1, 2014, the working-age population in Southern BMA comprised 76% of total population was 76% (108000 people). Infants and retired people comprised 23% (32430 people) and 19.2% (about 27000 people) of total population. The average life expectancy was 74.3 years (72.1 years for men and 76.5 years for women), which is close to the national figure (74.8 years).

The average density of population in Southern BMA in the same period was 31 people/km^2. This indicator has also decreased in the last few years, mainly due to low birth rates and migration. The Kapan town is the most densely populated area with 1500-1700 people/km^2, while the most sparsely populated are the villages located in the catchments of tributaries of the Araks River, 2-3 people/km^2 (Figure 1.8).

Living standards and social conditions: According to the National Statistical Service, unemployment rate in the Southern BMA comprised 5.9% of total population as of January, 2014. The poverty rate was 24.7% exceeding the indicator of 2009 by 4.2%. The number of extremely poor people in the same period comprised about 1.5% of total population.

As of January 2014, the number of families receiving allowance was 4131, the number of disabled people was 9940, including 269 of 1st category in Southern BMA. The pensioners amounted to 19.1% of the total population (Table 1.8). More than 500 families in need were living without elementary living conditions in dangerous homes and buildings.

Table 1.8: Statistical data on the vulnerable population groups in the Southern BMA, 2010-2013

Vulnerable groups	*2009*	*2010*	*2011*	*2012*	*2013*
Number of families receiving allowance	4964	4138	3383	3990	4131
Number of disabled people	8265	8604	8635	8639	9490
Number of pensioners	25505	25516	25524	25618	27015

Source: RA National Statistical Service

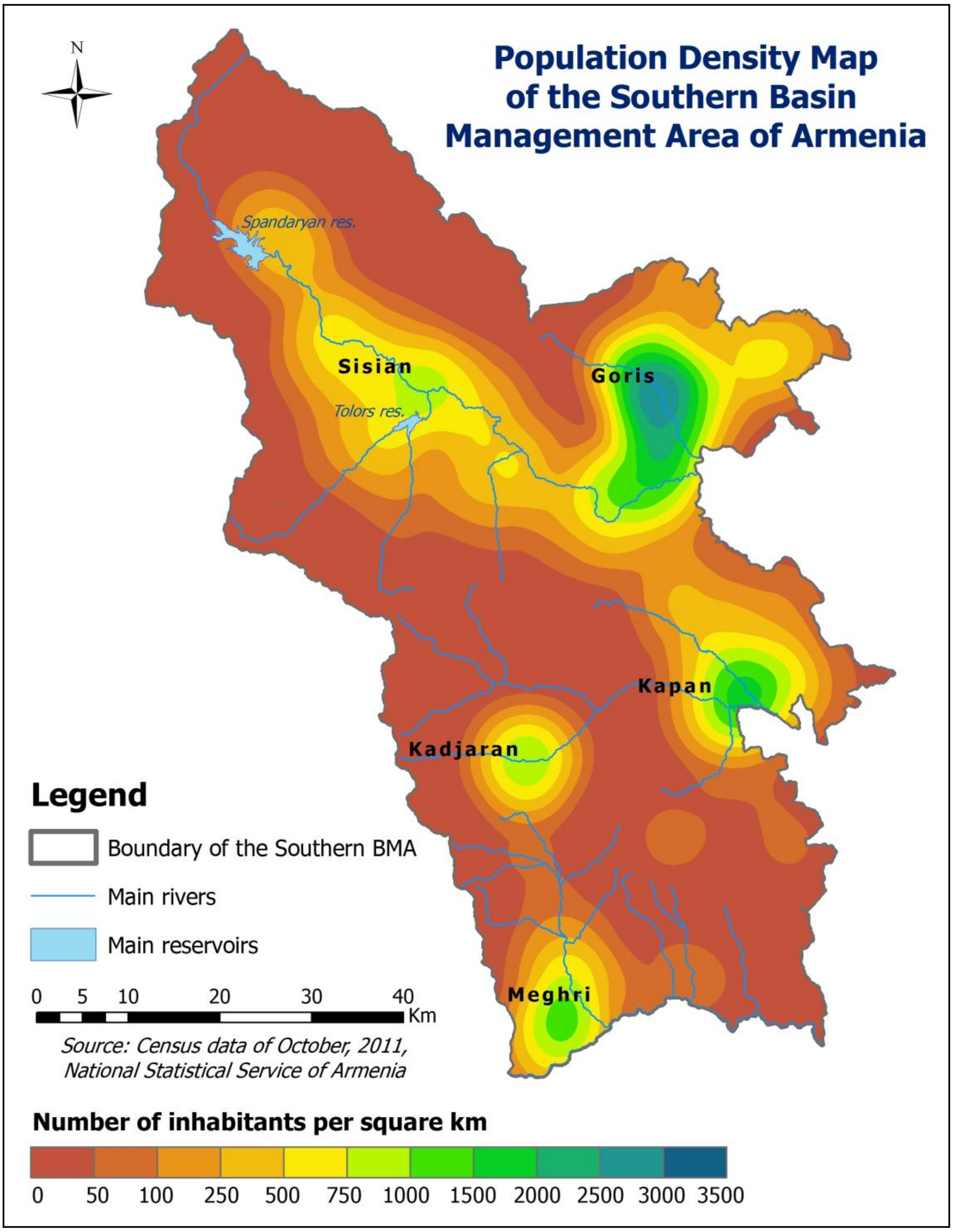


Figure 1.8: Population density in the Southern BMA

The source: RA National Statistical Service, 2011 population census (system of coordinates: WGS, UTM Zone 38N)

Health care: According to data from the Syunik marz Administration, there were 28 health care facilities in Southern BMA as of January 2014, including 5 medical centers (which are concentrated in urban areas), as well as 101 outpatient points in the rural communities.

According to the same source, in 2009-2013 sharp growth of oncology diseases among the population of the Southern BMA has been observed (conditioned by active diagnostics), as well as decreases of the tuberculosis incidences (due to the effective implementation of the national tuberculosis program).

At the same time, incidences of water-born infectious decease in the Southern BMA increased, due to aged and deteriorated drinking water supply infrastructure. Most of drinking water supply and wastewater systems in the communities within the Southern BMA are out aged and need capital repair. No wastewater treatment plants are available in the basin. As a result, there are frequent system failures leading to serious problems with providing water supply to the population in accordance with applicable norms. Furthermore, no sanitary protection zones are available at the main water intake structures and the water supplied to the population as a matter of fact is not disinfected.

Education and culture: The main educational and cultural centers are the Kapan and Goris towns.
There are 121 public schools with about 14435 students and 52 preschool institutions. There are also 17 music and art schools, 4 vocational, 7 intermediate vocational, 1 public higher educational institution, 1 private higher educational institution and 2 branches of higher education institutions.

1.1.8. Economy

This chapter is based on the data and materials received from the RA National Statistical Service, Syunik marz Administration and other respective institutions.

Overall economic performance: The Southern BMA has a great industrial potential, yet it remains a relatively sparsely populated and economically underdeveloped region, facing serious social-economic and demographic problems.

Industry and construction are the leading branches of economy in the Southern BMA. Mining industry and hydropower generation are dominating in the industry. There are also food, canned fruit, juices, textile products, sewing shops, aluminum and metal products, wood processing and small-scale production of wood products and electrical equipment, as well as mining auxiliary products.

According to the data of the National Statistical Service, the value of total goods produced in the Southern BMA in 2013 was 3279.5 million AMD (in current prices), which exceeds the same indicator from 2012 by AMD 14497.1 million. Industrial output constituted the main part – 63% of the total output (Table 1.9).

Table 1.9: Total volume of economic output in the Southern BMA in 2009-2013, million AMD

Fields of industry	***Years***				
	2009	***2010***	***2011***	***2012***	***2013***
Industry	94420.1	150606.1	178366.5	198723.7	204975.2
Agriculture	33400.0	36300.0	50400.0	57700.0	62400.0
Construction	22186.2	42580.2	38110.3	28289.2	24258.1
Trade	9110.3	11115.9	12102.4	15361.0	20698.8
Services	7209.3	8618.5	9425.4	11711.6	13601.8
Other Services	1124.6	1913.7	1728.2	1617.7	1527.4
Total:	**167450.5**	**251134.4**	**290132.8**	**313403.2**	**327461.3**

Source: RA National Statistical Service

Crop growing and mixed livestock production (cattle, sheep and goats breeding) are the main areas of economic activity of the communities in the Southern BMA. The majority of population was engaged in those sectors as of January 2014.

The administrative center of the Southern BMA is the Kapan town, which is one of the country's major industrial towns. The Kapan town, with a population of 45.7 thousand is located about 301 km away from Yerevan. The other industrial centers of the Southern BMA are the towns of Kajaran and Agarak. The Kajaran town is the center of non-ferrous metallurgy based on use of a rare copper and molybdenum deposit. The Sisian, Goris and Meghri towns are more known by processing industry and agriculture.

Industry: The main industrial sectors of the Southern BMA are mining and hydropower generation. The industry is relatively developed, which is related to the presence of major mining companies and associated industries servicing the mining companies, as well as the Vorotan Hydropower Plants (HPP) complex. About 83.1% of the industrial output of the Southern BMA is generated in the Voghji River Basin, predominantly in the mining industry. The remaining is generated in the Meghriget and Vorotan River Basins, comprising 14.3% and 2.6 % respectively.

Fifty seven 57 mines existing in the Southern BMA are poly-metallic, and 24 of them are non-ferrous.

The Zangezur, Kapan and Agarak Copper-Molybdenum Combines are the largest mining complexes - large scale companies and tax payers both regionally and nationally. Mining products are primarily composed of molybdenum, copper and zinc productions. Processing industry includes food, sewing, macadam, timber, tin, fence, furniture, metal and aluminum doors, worker's gloves and other industries. The annual mining output is approximately 8900 tons of copper and 428 tons of molybdenum concentrates.

The large share of power is generated in the Vorotan River Basin. The Vorotan HPP Complex alone generated 1016 GWh of electricity in 2013, which constituted 16% of the total energy generated in Armenia. It is a large economic structure not only in the Southern BMA, but also nationwide.

Food production and retail centers are concentrated in urban areas of the Southern BMA: Sisian, Goris, Kapan and Meghri towns.

A total industrial production in the Southern BMA amounted to 204975.6 million AMD (at current prices) in 2014, of which 82.9% was from mining industry, and the remaining 17.1% from other branches of industry. As of (Figure 1.9).

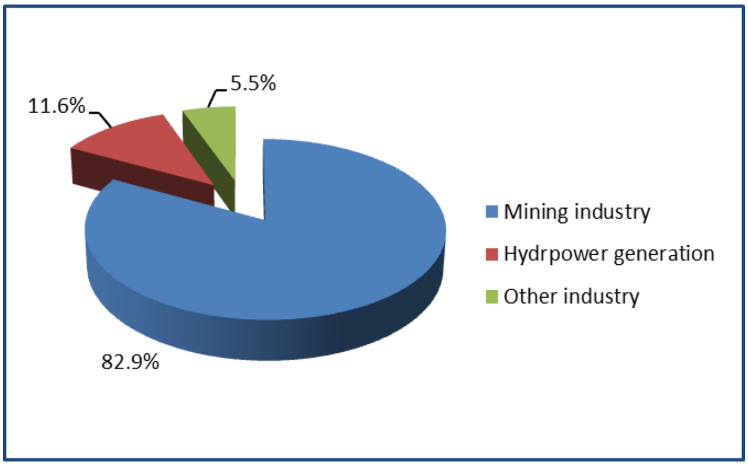


Figure 1.9: Volume of the industrial output in the Southern BMA as of January, 2014, %

Agriculture: The gross agricultural output in the Southern BMA comprised about 7.1% of Armenia's gross agricultural output in 2014.

Agriculture in the Southern BMA is mainly specialized in crop production, particularly, cereals and potatoes, and livestock production - cattle breeding.

The gross volume of agricultural products of the Southern BMA in 2014 was 62400 million AMD.

In 2014 the leading branch of agriculture was livestock production, mostly comprised of small and large cattle breeding (Table 1.10).

There were 3 livestock breeding farms in the Southern BMA, with the biggest in Kapan town with 900 cattle.
About 47.7% of agricultural lands in the Southern BMA are pastures, whereas 14.2% are arable lands, mostly is used for the cultivation of cereals and technical crops (Figure 1.10).

Table 1.10: Livestock capita in the Southern BMA as of January, 2014

River basin	*Households number*	*Cattle*	*Where, cows*	*Pigs*	*Small cattle*	*Rabbits*	*Poultry*	*Bee familie*	*Horses*	*Donkeys*	*Mules*
Vorotan	16850	42676	20219	5307	72268	1634	87043	23757	1698	578	15
Voghji	3438	10026	5107	3156	10954	504	50115	12485	519	247	41
Meghriget	1084	1392	596	456	2384	23	6259	3335	74	25	1
Total:	**22372**	**54094**	**25922**	**8919**	**85606**	**2161**	**143417**	**39577**	**2291**	**850**	**57**

The source: Syunik marz Administration, 2013

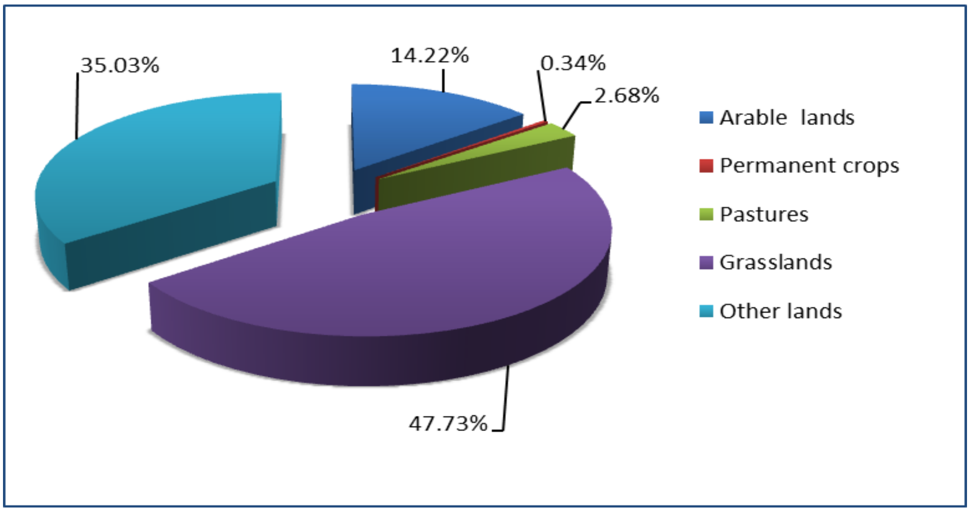


Figure 1.10: Agricultural lands of the Southern BMA as of 2013, %

Source: Syunik marz Administration, 2013

Cultivated areas are mainly scattered on the plateaus and river valleys in the Southern BMA. People in the low-lying areas are engaged in horticulture, viticulture, fodder crops, fruits and berries growing.

In 2013, 32500 ha out of 43835 ha of arable land in the Southern BMA was used for crops growing, particularly, for cultivation of cereals and cereal crops (71.5%) and potatoes, melons and gourds, grapes and fodder crops (28.5%). The crop production of the Southern BMA in 2009-2013 is presented in Table 1.11.

Table 1.11: Crop production in the Southern BMA in 2009–2013, quintal

Crop	*2009*	*2010*	*2011*	*2012*	*2013*
Cereals and other cereal crops	299730	145920	383210	540740	678248
Potatos	323710	236460	276170	280001	306560
Vegetables	174550	151370	157760	165100	172202
Fruits and berries	128590	124550	127760	129510	140103
Grapes	13784	14824	15608	15608	11951

Source: Syunik marz Administration, 2013

Transport and communication: The only transport sector available in Southern BMA is the motor vehicle road M-2 Yerevan-Yeraskh-Goris-Kapan-Meghri-Iran and M-17 Kapan-Shvanidzor-Meghri-Iran border interstate and M-12 Goris-Stepanakert automobile highways are passing here. Passenger and freight transport with Iran, Nagorno-Karabakh and other regions of Armenia takes place via these roads. The towns of the Southern BMA are connected with the rural communities of the region via local and national roads.

The annual turnover of goods by road was approximately 34.9 million tons/km, passenger traffic was 6.7 million people and passenger transportation -93.1 million passenger/km in Southern BMA as of January, 2014.

These rates are higher compared with other BMAs of the country due to the interstate highways passing through the Southern BMA.

Tourism and recreation: The Southern BMA is rich with scenic and healthy nature, healing water springs, forests, mountains, historical and cultural and natural monuments and sights. The significant and main role for tourism, including development of eco-tourism is played by Tatev monastery complex, "Wings of Tatev" ropeway, Karahunj Observatory, the world's largest natural grove of pine trees relic in the Tsav River Gorge, Vahanavank (X century) one of the religious and cultural centers of historical Syunik, the Shikahogh (Red Soil) reserve and Arevik National Park.

According to the Government No. 973-N Decree of June 10, 2011 of Goris town was declared a tourism center. Given the position of Goris, the nature and artistic value of the cultural monuments existing in the town, it is possible to create a cultural center in the city's historic area -Old Goris cultural reserve.

The service sector is still in the development stage in the Southern BMA: there are new hotels, which, however, are still not able to provide average service conditions, which is a significant obstacle for the development of tourism. The significant distance from the capital city is also considered as an obstacle.

As of January, 2014, 32 hotels and private hotels were operating in the Southern BMA. Concepts on regional tourism development are prepared and implemented by Syunik marz Administration and international development programs. Development of tourism and recreation will contribute to the increase of the number of jobs in the service industry and development of the sector itself.

1.2. General Hydrological and Hydrogeological Characteristics of the Southern Basin

The hydrological and hydrogeological characteristics of the Southern BMA were provided based on data from the Armenian State Hydrometeorological and Monitoring Service under the RA MTAES, and Hydrogeological Monitoring Center SNCO under the RA MNP.

1.2.1 Surface Water Resources

Rivers: The surface water resources of the Southern BMA belong to the Vorotan, Voghji and Meghriget River Basins.

The Vorotan River is the largest tributary of Araks in the Zangezur area. It begins in the North-Eastern Syunik plateau and eastern slopes of the Zangezur Mountain Range from the small lakes and springs and flows into the River Araks beyond the borders of the Republic of Armenia. The total length of the river is 178 km (111 km within the RA), with a total catchment area of 5650 km^2, of which 2596.81 km^2 within the Republic of Armenia. The largest tributary of Vorotan River is the Sisian River. The Gorisget and Qashun Rivers are discharging in to the Vorotan River outside the Republic of Armenia (Table 1.12).

The Voghji River Basin includes the Voghji and Tsav Rivers with their tributaries. The Voghji River is the second largest river of the Southern BMA. It originates from the small lakes and springs on the slopes of Kaputjugh of the Zangezur Mountain Range. The river's total length is 82 km (52 km within RA), with the catchment area of 2337 km^2 (1240.47 km^2 within RA). The largest tributary is the Geghi River. Other major river in the basin is Tsav (Table 1.12).

Meghriget is the main river in the Meghriget River Basin. It originates from the small lakes and springs on eastern slopes of the Zangezur Mountain Range and flows into the Araks River downstream the Meghri town. The river length is 36 km, catchment area is 336.3 km^2. The Ayrijur is the major tributary of Meghriget River. The Karchevan (10 km), Karavget (13 km), Malev (18 km), Astghadzor (Astazurget - 17 km), Shavigh (Shavzir- 13 km) and Nrnadzor (Nyuvadi - 14 km) are other tributaries of the Meghriget River that are discharging into the Araks River (Table 1.12).

Table 1.12: General morphometric characteristics of the rivers of the Southern BMA

Name of the river	*Main river*	*Altitude at head-waters, m*	*River mouth elevation, m*	*Length, km*	*Average slope, ‰*	*Surface of the catchment area, km^2*
Vorotan	Araks	3045	720	111*	21	2596.9*
Tsghuk	Vorotan	3080	1998	26	42	139
Sisian	Vorotan	3040	1542	33	45	395
Qashun	Vorotan	2250	890	32,3*	-	99.8
Gorisget	Vorotan	3200	820	25*	95	144
Loradzor	Vorotan	3180	1340	23	42	12
Tatev	Vorotan	2850	974	11,3	166	84.2
Shaqi	Vorotan	3363	1623	17,4	100	44
Voghji	Araks	3650	640*	52,0*	58	1240.3*
Geghi	Voghji	3260	1265	29,7	67	308.3
Norashenik	Voghji	2300	674	26,8	61	130.1
Artsvanik	Voghji	1784	674	17,1	65	46.7
Geghanush	Voghji	2850	685	17,0	127	50.1
Vatchagan	Voghji	2800	765	11,8	172	35.2
Tsav	Araks	2500	650*	27,0*	69	252.1
Neghriget	Araks	3600	513	36	92	336.3
Kartchevan	Araks	2350	535	10	192	28.2
Karavget	Araks	2050	488	13	161	23.0
Malev	Araks	2650	474	18	148	50.4
Astghadzor (Astazurget)	Araks	2650	451	17	106	35.0
Nrnadzor (Byuvaghi)	Araks	2100	412	14	140	53.6
Shavigh	Araks	2050	442	13	146	31.3

* - within Armenia

Source: Armenian State Hydrometeorological and Monitoring Service SNCO, RA MTAES

The rivers of the Southern BMA are typical mountain with fractured relief and developed hydrographic network in the catchment basin. The rivers at the upper streams have large inclination and are fast flowing.

The average density of the river network in the Southern BMA is 1.36 km/km^2, which exceeds the country indicator (0.85 km/km^2). The total number of rivers is more than 2985 with a total length of 5528 km. Only the Vorotan River alone is having 100 km length. By their length 97% of rivers are shorter than 10 km. (Table 1.13).

Table 1.13: River network characteristics in the Southern BMA

River basins	***Vorotan***		***Voghji***		***Meghriget***		***Southern BMA***	
Rivers by their length	*Cumulative length, km*	*Number of rivers*	*Cumulative length, km*	*Number of rivers*	*Cumulative length, km*	*Number of rivers*	*Cumulative length, km*	*Number of rivers*
Shorter than 10 km	1690	1100	1737	1152	761	655	4188	2907
10-25 km	477	34	304	20	201	16	982	70
25-50 km	88	3	59	2	36	1	183	6
50-100 km	-	-	56	1	-	-	56	1
100 km and more	119	1	-	-	-	-	119	1
Total river network	2374	1138	2156	1175	998	672	5528	2985

River basins	Vorotan		Voghji		Meghriget		Southern BMA	
Rivers by their length	*Cumulative length, km*	*Number of rivers*	*Cumulative length, km*	*Number of rivers*	*Cumulative length, km*	*Number of rivers*	*Cumulative length, km*	*Number of rivers*
Surface of the river basins, km^2	2596.9		1240.3		660.7		4498	
Density indicator of the river network, km/km^2	0.95		1.66		1.49		1.36	

Source: Armenian State Hydrometeorological and Monitoring Service SNCO, RA MTAES

The hydrological network of the Southern BMA is highly uneven in distribution. The right bank section of Vorotan River is denser than the left bank, due to the volcanic rocks and high infiltration rate in the Syunik volcanic shield. The tributaries on the left side of the Voghji River are more full-flowing than on the right side due to the level of forest coverage on the right bank and volume of surface flow in the left side section. The river network is sparse in the catchment areas of rivers in the Meghriget River that are discharging into the Araks River, and flow is seasonal.

Due to the steep and fragmented nature of topography in the Southern BMA, the rivers have big inclinations. Below are the general characteristics from the hydrological observation posts (Table 1.14).

Table 1.14: General characteristics of the river catchments in the hydrological observation posts of the Southern BMA

River – observation post	*Catchment, km^2*	*Average altitude, m*	*Average slope,‰*	*Forest cove,%*
Vorotan-Gorhayk	*268*	*2710*	*197*	*0*
Vorotan-Vorotan	*1550*	*2370*	*164*	*3*
Vorotan – Tatev HPP	*1988*	*2280*	*152*	*4*
Tsghuk-Tsghuk	*85*	*2790*	*131*	*0*
Sisian-Arevis *	*118*	*2520*	*297*	*1*
Loradzor-Ltsen *	*118*	*2320*	*438*	*4*
Tatev - Tatev *	*84.2*	*1990*	*166*	*0*
Gorisget-Goris	*65*	*2180*	*324*	*5*
Voghji–Kajaran t.	*120*	*2840*	*465*	*6*
Voghji –Kapan t.	*710*	*2380*	*476*	*18*
Geghi-Kavtchut	*272*	*2600*	*474*	*7*
Norashenik-Norashenik *	*96.0*	*1650*	*388*	*37*
Vachagan - Kapan t.	*35.0*	*1541*	*376*	*71*
Geghanush - Geghanush*	*44.8*	*1820*	*485*	*54*
Tsav-Rozdere (Nerqin Hand)*	*252*	*1732*	*450*	*72*
Meghriget-Litchq*	*21.0*	*2548*	*158*	*17.1*
Meghriget-Meghri	*274.0*	*2074*	*92*	*26.9*
Kartchevan-Agarak*	*19.0*	*1423*	*192*	*29.8*
Astazurget-Shvanidzor *	*32.5*	*1567*	*106*	*35.5*

* - closed observation posts

Source: Armenian State Hydrometeorological and Monitoring Service SNCO, RA MTAES

River flow is unevenly distributed during the year. The water regime is characterized by snowmelt and rainfall floods. More than half of the flow passes during the spring (March-June), while the lowest flow is observed in the winter period (Table 1.15). About 15-40% of the total annual river flow occurs in the summer-autumn and winter low-water periods (Table 1.16), and small rivers in the Meghriget River Basin that are discharging into the Araks River are getting dry in summer.

Table 1.15: Intra-annual distribution of the river flow in the Southern BMA

River – observation post	*I*	*II*	*III*	*IV*	*V*	*VI*	*VII*	*VIII*	*IX*	*X*	*XI*	*XII*
Vorotan-Gorhayk	2.28	2.28	2.46	5.30	9.36	9.02	4.30	2.80	2.54	2.33	2.28	2.27
Vorotan-Vorotan	3.97	4.48	4.90	7.70	6.62	5.49	5.04	4.98	5.24	4.89	4.43	4.12
Vorotan – Tatev HPP	20.3	18.8	17.9	26.0	23.6	23.7	16.7	17.9	17.7	18.3	18.2	18.8
Tsghuk-Tsghuk	0.66	0.60	0.63	1.78	6.16	4.60	0.85	0.30	0.28	0.40	0.70	0.71
Gorisget-Goris	0.39	0.41	0.47	0.64	0.73	0.52	0.25	0.27	0.37	0.40	0.38	0.36
Voghji – Kajaran t.	0.54	0.36	0.82	3.09	7.82	11.9	7.52	2.70	1.05	0.72	0.67	0.57
Voghji – Kapan t.	2.47	2.72	4.99	15.8	32.0	31.3	16.6	6.63	4.03	3.84	3.43	2.89
Geghi- Kavtchut	0.95	0.99	1.70	6.42	13.3	13.1	6.88	2.82	1.56	1.44	1.28	1.09
Vachagan - Kapan t.	0.19	0.23	0.58	1.22	1.09	0.58	0.29	0.23	0.27	0.24	0.24	0.21
Tsav-Rozdere (Nerqin Hand)*	0.38	0.43	0.76	3.17	8.82	10.5	5.98	1.76	0.92	0.60	0.38	0.32
Meghriget-Litchq	0.09	0.09	0.13	0.47	1.32	2.41	1.53	0.52	0.19	0.14	0.13	0.11
Meghriget-Meghri	0.89	0.97	2.01	5.37	7.66	8.28	4.21	1.36	0.77	0.92	1.08	0.96
Kartchevan-Agarak	0.02	0.03	0.07	0.12	0.13	0.05	0.02	0.01	0.01	0.02	0.02	0.02
Astazurget-Shvanidzor	0	0	0.097	0.15	0.16	0.091	0.055	0.031	0	0	0	0

Source: Armenian State Hydrometeorological and Monitoring Service SNCO, RA MTAES

Table1.16: Main characteristics of the multiyear average annual flow in the rivers of the Southern BMA in the hydrological observation posts

River – observation post	*Catchment area, km²*	*River flow*					
		Module l/sec km²	*Average annual discharge, m³/sec*	*Discharge volume, million m³*	*Seasonal distribution, %*		
					III-VI	*VII-X*	*XI-II*
Vorotan-Gorhayk	268	14.7	3.94	124	56	28	16
Vorotan-Vorotan	1550	3.12	4.84	153	61	27	12
Vorotan – Tatev HPP	1988	9.91	19.8	625	60	27	13
Tsghuk-Tsghuk	85.0	17.0	1.45	45.8	68	17	15
Gorisget-Goris	65.0	6.44	0.42	13.2	47	35	17
Voghji – Kajaran t.	120	26.3	3.16	99.67	58	37	7
Voghji – Kapan t.	710	14.9	10.6	334.3	62	31	8
Geghi-Kavtchut	272	15.8	4.29	135.3	59	33	8
Vachagan - Kapan t.	35.0	11.4	0.40	12.6	64	20	16
Meghriget-Meghri	274.0	10.5	2.87	90.5	68	21	11

Source: Armenian State Hydrometeorological and Monitoring Service SNCO, RA MTAES

The area-specific river flow (flow module) observed in hydrological observations points in the Southern BMA are within the range of 3-26 l/sec km^2. The area-specific flow the lowest values is observed at the lower reaches of rivers, 2-3 l/sec km^2, while the highest values– at the near-peak and higher segments, 15-30 l/sec km^2 (Figure 1.11).

The maximum flow in rivers of the Southern BMA is observed during spring and summer floods, and minimum flows are occurring in summer and dry winter periods (February and August).

Table 1.17 presents the maximum and minimum discharge data that were ever recorded in the hydrological observation posts of the Southern BMA.

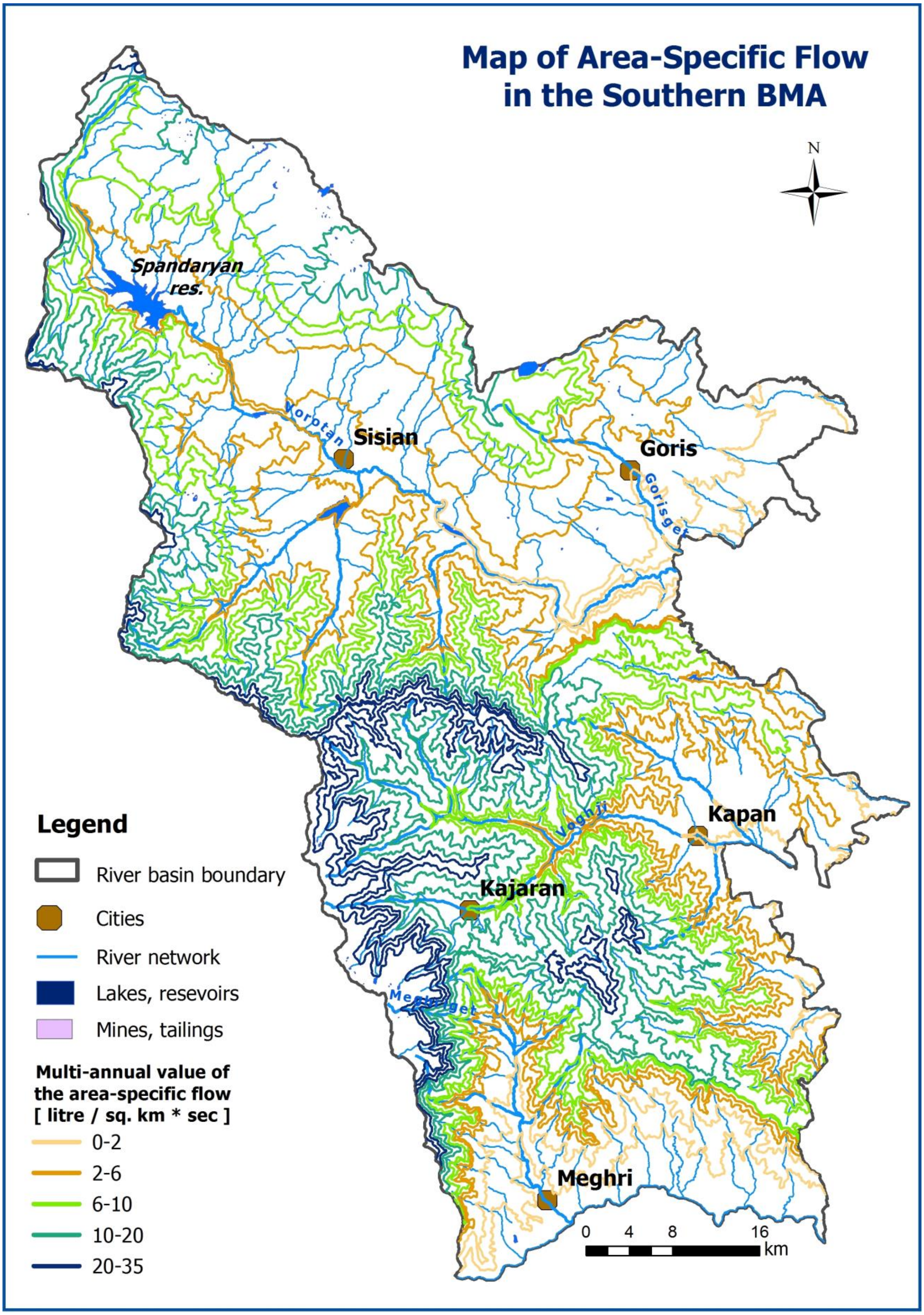


Figure 1.11: Area-specific flow map of the Southern BMA

Source: Armenian State Hydrometeorological and Monitoring Service SNCO, RA MTAES, 2012 (system of coordinates: WGS, UTM Zone 38N)

Table 1.17: Maximum and minimum discharges observed at the hydrological observations posts of the southern BMA, m^3/sec

River – hydrological observation post	Catchment area, km^2	River flow	
		Maximum discharge	Minimum discharge
Vorotan-Gorhayk	268	27.2	1.2
Vorotan-Vorotan	1550	300 / 67.2 **	1.83/1.3 **
Vorotan – Tatev HPP	1988	1140 / 141 **	0.2/ 1 **
Tsghuk-Tsghuk	85.0	46.6	0.071
Sisian-Arevis*	118	49.7	0.17
Loradzor-Ltsen*	118	25.3	0.043
Tatev - Tatev *	84.2	27.8	0.062
Gorisget-Goris	65.0	46.4	0.021
Voghji – Kajaran t.	120	32.4	0.09
Voghji – Kapan t.	710	270	0.30
Geghi-Kavtchut	272	37.8	0.31
Norashenik–v.o. Norashenik *	96.0	34.7	0.035
Vachagan – Kapan t.	35.0	17.2	0.006
Geghanush- Geghanush *	44.8	21.3	0.004
Tsav-Rozdere (Nerqin Hand)*	252.1	17.1	0.042
Meghriget-Litchq*	21.0	7.61	0.01
Meghriget - Meghri	274.0	87.5	0.08
Kartchevan-Agarak*	19.0	0.72	0.003
Astazurget-Shvanidzor*	32.5	20.2	0.0

** - closed observation posts*

* *- before construction of the reservoir/after construction of the reservoir

Source: Armenian State Hydrometeorological and Monitoring Service SNCO, RA MTAES

Ice formation is observed in the upper reaches of rivers and their tributaries of the Southern BMA, while in the lower reaches it is observe not each year.

The rivers and their tributaries in Southern BMA are having mixed feeding sources. Several tributaries of the Vorotan, Voghji and Meghriget Rivers are basically fed by the melting snow, feeding from the groundwater supply is mostly observed in the middle and lower streams of the Vorotan River - 50-56%, and the Gorisget River -70% (Table 1.18).

In the upper areas of the Voghji and Meghriget River Basins during, due to the large amounts of snow accumulation, presence of snow and firn zones in winter time, feeding of the rivers by the melting is significantly greater -50% and more.

Due to the low precipitation and small number of springs in the catchments of the small tributaries of the Araks River, feeding sources are distributed almost evenly (Table 1.18).

Table 1.18: Feeding Sources of the rivers in the Southern BMA, %

River – hydrological observation post	Catchment, km^2	Source of feeding		
		Snowmelt	Rainfall	Groundwater
Vorotan-Gorhayk	268	42	12	46
Vorotan–Tatev HPP	1988	33	11	56
Vorotan - Vorotan	1550	39	11	50
Tsghuk-Tsghuk	85	50	10	40
Sisian-Arevis*	118	55	13	32
Loradzor-Ltsen*	118	52	12	36
Tatev - Tatev *	84.2	53	13	34
Gorisget-Goris	65	18	12	70
Voghji – Kajaran t.	120	57	20	23
Voghji – Kapan t.	710	56	13	31

River – hydrological observation post	Catchment, km^2	Source of feeding		
		Snowmelt	Rainfall	Groundwater
Geghi-Kavtchut	272	53	25	22
Norashenik –Norashenik *	96.0	25	36	39
Vachagan - Kapan	35.0	37	28	35
Geghanush- Geghanush *	44.8	31	32	37
Tsav-Rozdere (Nerqin Hand)*	236.5	36	30	34
Meghriget-Litchq*	21.0	51	19	30
Meghriget - Meghri	274.0	50	18	32
Kartchevan-Agarak*	19.0	37	30	33
Astazurget-Shvanidzor*	32.5	35	39	26

** - closed observation posts*

Source: Armenian State Hydrometeorological and Monitoring Service SNCO, RA MTAES

Lakes: The small mountain lakes in the Southern BMA are spread at 2300-3500 m above sea level. There are many in the Vorotan River Basin - more than 90 small lakes, most of which are drying in summer. There are few lakes and ponds in the Meghriget and Voghji River Basins -14 and 4, respectively.

Lakes are mainly of tectonic and glacial origin, and the lakes of the Syunik Volcanic Shield are of volcanic and volcano-glacial origin. Glacial lakes are surrounded by lateral moraines.

Lakes are mainly of mixed feeding: dominated by melting. The total volume of lakes varies, depending on the season of year. Lakes water is clean, clear, colorless, and suitable for drinking and technical purposes. The lake water is used for drinking and irrigation purposes. Lakes, apart from the Sev Lake, are almost lacking any fish.

Hydrological and hydrographic characteristics of some lakes in the Southern BMA are given below (Table 1.19).

Table 1.19: Hydrological and hydrographic characteristics of lakes in Southern BMA

Name of the lake	*Location*	*Catchment area, km^2*	*Altitude, m*	*Max depth, m*	*Average depth,*	*Length, m*	*Max width, m*	*Water table, ha*	*Volume, million m^3*
Vorotan River Basin, small lakes of the Zangezur Mountain Range									
Antak	Right tributary of the Vorotan River, at the upper streams of the Argili River	0.18	2335	5.8	1.58	203	122	2.48	0.039
Vorotan River Basin, small lakes of the Syunik Plateau									
Sev	13 km to the north-west of the Goris town, 5 km east from Mets Ishkhanasar mountain	12.0	2658	10.0	4.84	1875	1107	185	8.74
Al (Aylakh)	15 km north-east from the village of Sarnakunq	34.2	2984	2.8	1.94	1150	460	52.9	1.02
Zuygaghbyur 1	14 km north-east from the village of Sarnakunq	0.68	3098	2.50	0.85	170	90	1.09	0.010
Zuygaghbyur 2	14 km north-east from the village of Sarnakunq	0.68	3098	2.30	0.49	210	80	1.25	0.006
Qari Litch (Ukhtasar)	2 km north-west from the village of Tsghuk	0.57	3274	5.0	1.91	235	130	1.42	0.071

Name of the lake	Location	Catchment area, km^2	Altitude, m	Max depth, m	Average depth,	Length, m	Max width, m	Water table, ha	Volume, million m^3
Khalash	12 km north from the village of Sarnakunq	1.93	3015	12.9	5.30	400	210	6.23	0.326
Voghji River Basin									
Gazan	In the springs of Ajabaj tributaries in the upper stream of river Geghi, in the near the top parts in the East-North Eastern direction of Zangezur Mountain Range	2.98	3112	7.7	3.2	400	120	4.8	153.6
Kaputan	In the springs of Kajaran tributary of river Voghji, in the North Eastern direction of Zangezur Mountain Range	2.70	3286	22	3.6	586	265	13.0	468.0
Tsakqar(Sakkar)	In the springs of Tsakqar tributary of river Voghjiin the North Eastern direction of Zangezur Mountain Range	2.46	3272	6.0	3.6	330	102	3.19	112.0
Ananun	In the spring of left branch of Kajarants tributary of the Voghji River, north-eastern slope of the Zangezur Mountain Range	0.28	3550	3.0	0.7	100	50	0.5	3.5
Meghriget River Basin									
Gogi	In the headwaters of the Meghriget River, 8 km to the west of Lichk community	1.30	3290	8	3.40	120	90	10.8	0.037
Khurjin	600 m to the south-east of Lake Kaputan	0.33	3445	7	3.20	105	85	9	0.029

Source: Armenian State Hydrometeorological and Monitoring Service SNCO, RA MTAES

1.2.2. Groundwater Resources

The groundwater basins in the Southern BMA are related with volcanic, lacustrine and riverine, volcanic and sedimentary, intrusive rocks. In the mountainous areas the groundwater resources are of local distribution, groundwater aquifers are wide spread in the flood plains and concavities.

Operational groundwater reserves in the Southern BMA were approved for the Vorotan River Basin only in 1968, 429 million m^3/year (Table 1.20).

The operational groundwater resources in the Voghji and Meghriget River Basins have not been approved by the state and territorial commissions. Groundwater resources in the Voghji River Basin, according to the multiyear average values, comprise 185.1 million m^3/year, while in the Meghriget River Basin -59.21 million m^3/ year (Table 1.20).

Table 1.20: Groundwater resources in the Southern BMA

N/n	River basin	Groundwater resources by flow components, million m^3/year			Deep flow
		Total	Spring flow	Drainage flow	
1	Vorotan	429	114	208	107
2	Voghji	185.1	72.2	26.5	86,4
3	Meghriget	59.21	28.35	25.83	5,03
Total		**673,31**	**214.55**	**260.33**	**198.43**

Source: Hydrogeological Monitoring Center of the RA MNP

Springs and kyahrizes (groundwater channels): The major springs of the Southern BMA are spread in the Vorotain River valley and slopes of the Syunik Volcanic Plateau, in the upper and middle reaches of the Voghji and Geghi Rivers, the upper reaches of the Meghriget River and near town of Agarak. Kyahrizes are mostly found in the vicinity of the Nrnadzor and Shvanidzor settlements (Table 1.21).

Table 1.21: Major springs and kyahrizes in the Southern BMA

Name	Location	Elevation, m	Discharge, l/sec
Vorotan River Basin			
Shaqi	1.2 km to the south of Shaqi village	1720	1400
Zor-Zor	0.6 km to the south-west of Vaghatin village	1650	290
Mukhuturyan	6.5 km to the north of Sarnakunq village	2610	200-280
Akner	Basin of Gorisget, south-eastern slopes of the Mets Ishkhanasar	2050	80-120
Sevaghbyur	1 km to the north-east from the town of Sisian	1650	15
Gorhayk	4.8 km to the north-west from Gorhayk	2070	200
Angeghakot	2.7 km to the south-east from the village of Angeghakot	1750	350
Urut	In the northern part of the Vorotan village	1400	80
Sisian	Eastern part of Sisian town	1600	25
Voghji River Basin			
Jrakhor	In the western end of the town of Kapan, at the left bank springs of the Voghji River	1190	7
Ajabaj	Springs of the Ajabaj River	2104	200
Vachagan	3 km to the western from the village of Vachagan	1630	4
Geghi	To the north from the village of Geghi	1550	50
Gyard	To the west from the village of Geghi, in the lower stretch of the Gyard right-bank tributary of the Geghi River	1650	150
Surin kap	In the middle reaches Voghji River, 2 km to the east eastern from the Nerqin Giratagh village	1405	25
Tchanakhtchi	In the upper reaches of the left-bank Tchanakhchi of the Voghji River	1325	60
Halidzor	In the Southern part of the town of Kapan	977	2.9
Meghriget River Basin			
Springs of Lichk	3.4 km to the north-west from the village of Lichk	2350 – 2500	28
Tashtun springs	2.5 km to the north-west from the village of Tashtun at the absolute elevation of 2400 m	2400	36
Springs of Kaler	1.7-3.1 km to the north-east from the village of Kaler	2225 – 2750	3.2
Kyahriz (Underground channel)	In Nrnadzor	600	1.4
Kyanriz (Underground channel)	In the village of Shvanidzor	650	3.9
Sosu –Garan spring	4.5 km on the north-west from the town of Agarak	1645	1.3

Source: Hydrogeological monitoring Center

1.2.3. Water Balance

The water balance of the Southern BMA was calculated using the standard **X = Y + E** equation, where X is the quantity of atmospheric precipitation, Y- the river flow and E – cumulative evaporation.

Every component of the water balance was linked to the altitudes of the observed area, by months. The average balanced altitudes of the catchment were then used to calculate the average values of these components (Tables 1.22 and 1.23). The rivers of the Meghriget River Basin discharging into the Araks River not included in the water balance of the Southern BMA due to their temporary flow.

Table 1.22: Southern BMA water balance, by ascending zones

Ascending zones, m	*Surface, km^2*	*Precipitation million m^3 / mm*	*Evaporation million m^3 / mm*	*Natural river flow, Mln. m^3 / mm*			*Deep flow, million m^3 / mm*
				Total million m^3 / mm	*Surface flow, million m^3 / mm*	*Groundwater flow, million m^3 / mm*	
Over 3000	416.03	392.3 943	84.3 203	238 572	124 297	114 275	74.9 180
3000-2000	2112.76	1665 788	641 303	733 347	425 201	308 146	285 135
2000-1000	1602.34	939.0 586	617 385	329 205	194 121	135 84	-12.8 -8
Up to 1000	366.76	164.7 449	161 440	20.5 56	13.6 37	6.96 19	-9.2 -25
Total:	4497.89	3161 703	1503 334	1320 293	756 168	564 125	338 76

Table 1.23: Multiyear average annual values of the water balance elements of the Southern BMA by river basins

River basin	*Surface, km^2*	*Precipitation million m^3 / mm*	*Evaporation million m^3 / mm*	*River natural flow, million m^3 / mm*	*Deep flow, million m^3 / mm*
Vorotan	2596.81	1872 721	861 332	764 294	247 95
Voghji	1240.47	924 745	409 330	429 346	86 69
Meghriget	660.61	365 553	233 353	127 192	5 8
Southern BMA	4497.89	**3161 703**	**1503 334**	**1320 293**	**338 76**

Values of the multiyear river discharge during various periods are presented below in Table 1.24. The values of river flow availability were taken from the curves of river discharge during low-, medium- and high-water periods for each hydrological observation post (Annex A)

Table 1.24: Characteristics of the rivers discharge in the Southern BMA
Numerator – water discharge (Q, m3/sec, denominator – flow volume (W, million m^3)

River – hydrological observation post	*Catchment area, km^2*	**River flow**						
		Multi-year average	*2013*	**Types of year in terms of water availability**				
				25%	*50%*	*75%*	*95%*	*99%*
Vorotan - Gorhayk	268	3.76 118.6	2.97 93.67	4.14 130.6	3.72 117.3	3.10 97.77	2.10 66.23	1.52 47.94
Vorotan -Angeghakot	643	10.7	8.40	12.4	10.6	9.42	6.58	4.97

River – hydrological observation post	*Catchment area, km²*	River flow						
		Multi-year average	*2013*	Types of year in terms of water availability				
				25%	*50%*	*75%*	*95%*	*99%*
		337.5	264.9	391.1	334.3	297.1	207.5	156.8
Vorotan - Vorotan	1550	18.3 577.2	15.0 473.1	20.1 634.0	18.1 570.9	15.4 485.7	10.1 318.6	9.18 289.5
Vorotan –Tatev HPP	1988	21.3 671.8	17.1 539.3	24.2 763.3	20.9 659.2	17.5 552.0	12.8 403.7	10.9 343.8
Tsghuk-Tshghuk	85	1.62 51.1	1.19 37.53	1.85 58.35	1.61 50.78	1.30 41.02	0.85 26.81	0.60 18.92
Sisian-Ashotavan*	204	3.80 119.9	3.40** 107.2	4.40 138.8	3.65 115.1	3.15 99.35	2.06 64.97	1.42 44.79
Sisian -Arevis*	118	1.88 59.30	1.71** 53.93	2.03 64.03	1.87 58.98	1.64 51.73	1.09 34.38	0.85 26.81
Loradzor-Ltsen*	118	1.01 31.86	0.84** 26.49	1.15 36.27	0.98 30.91	0.86 27.12	0.55 17.35	0.42 13.25
Tatev - Tatev *	84.2	2.02 63.71	1.73** 54.56	2.32 73.17	1.85 58.35	1.76 55.51	1.28 40.37	1.07 33.75
Gorisget-Goris	65	0.71 22.39	0.79 24.92	0.82 25.86	0.73 23.02	0.59 18.61	0.30 9.46	0.19 5.99
Voghji–Kajaran t.	120	3.31 104.4	2.06 64.97	4.16 131.2	3.32 104.7	2.55 80.43	1.56 49.20	1.18 37.22
Voghji – Kapan t.	710	10.61 334.6	6.30 198.7	13.4 422.6	10.7 337.5	7.61 240.0	5.24 165.3	4.60 145.1
Geghi - Geghi*	195	4.64 146.4	4.22** 133.1	5.52 174.1	4.60 145.2	3.56 112.3	3.10 97.77	1.85 58.35
Geghi - Kavtchut	272	5.10 160.9	3.89 122.7	6.10 192.4	5.02 158.3	4.18 131.8	3.37 106.3	2.10 66.23
Norashenik– Norashenik *	96.0	1.13 35.64	0.75** 23.66	1.46 46.05	1.13 35.64	0.75 23.66	0.59 18.61	0.53 16.72
Vachagan –Kapan t.	35.0	0.42 13.25	0.57 17.98	0.48 15.14	0.38 11.99	0.30 9.46	0.24 7.57	0.21 6.62
Geghanush- Geghanush *	44.8	0.54 17.03	0.39** 12.30	0.69 21.76	0.51 16.09	0.39 12.30	0.28 8.83	0.22 6.94
Meghriget-Lichk*	21.0	0.63 19.87	0.81** 25.55	0.72 22.71	0.61 19.24	0.53 16.72	0.38 11.99	0.32 10.09
Meghriget - Meghri	274.0	3.18 100.3	3.91 123.3	3.54 111.7	3.10 97.77	2.51 79.17	1.52 47.94	1.35 42.58

* - closed observation posts, **- restored value of the river flow

1.2.4. Classification of Water Resources

The rivers of the Southern BMA were classified according to the provisions of the EU WFD and RA Law on National Water Program.

According to the scale of absolute elevations proposed by the EU WFD the rivers of the Vorotan, Voghji and Meghriget River Basins are characterized as highland.

The Vorotan and Voghji River Basins, according to the size of catchment areas proposed by the EU WFD, are divided into small, medium and large areas and the Meghriget River Basin is split into small and medium areas.

The third classifier of the river basins according to the EU WFD is geology, which takes into account the types of the rocks that form the river basin, depending on their origin and composition. The Vorotan River

Basin of Vorotan is represented by two types of rocks only: limestone and silicates, the Voghji – by limestone and Meghriget – by silicates (Table 1.25).

Table 1.25: Classification of the rivers in the Southern BMA, according to the EU WFD

Name of the river	*According to absolute altitude, m*			*According to catchment area, km²*				*According to geological characteristics*		
	> 800	*200-800*	*< 200*	*10-100*	*100-1000*	*1000-10000*	*> 10 000*	*Organic*	*Limestone*	*Silicates*
Vorotan	2210*					1988*			+	+
Tsghuk	2718				139					+
Mukhuturyan	2763			49						+
Arigliget	2291			95					+	
Sisian	2266				396				+	
Ayriget	2262				170				+	
Vaghudi	2281			32						+
Loradzor	2293				119				+	
Tatev	2145			84					+	
Gorisget	1974				144					+
Qashun	1953				100					+
Shaqi	2105			44					+	
Voghji	2237*					1043.0*			+	
Geghi	2499				308.3				+	
Tsav	1732*				252.1*				+	
Vachagan	1541			35.2					+	
Geghanush	1736			50.1					+	
Norashenik	1478				130.1				+	
Meghriget	2061				336.3					+
Astazurget	1554			35.0						+
Nrnadzor	1261			53.6						+
Kartchevan	1406			28.2						+
Malev	1615			50.4						+
Karavget	**1446**			**23.0**						+

* - up to the RA border

According to the RA Law on the National Water Program, water resources are classified according to:

- Significance: international, national and local;
- Sources of feeding: snow melt, rainfall, groundwater;
- River length: long (50 km and more), average (25-50 km), short (10-25 km) and minor (10 km and less);
- Level of water availability: high-flow/abundant, medium-flow and low-flow/dry;
- Distribution of flow over the years: even distribution, uneven distribution and having regime of sharp changes;
- Purpose of use: drinking-municipal, irrigation, industrial, energy, fishery and recreation.

The Vorotan, Voghji, Meghriget and Tsav Rivers of the Southern BMA are of international significance and their tributaries –of national and local.

The rivers are having both snow melt and mixed feeding, which means that the significant part of the rivers is fed by waters from the snow accumulation and melt, and the rest are almost evenly fed from the rains, groundwater resources and snow melt. Only in the Vorotan River the groundwater feeding is prevailing.

By the river length, only the Vorotan is considered as long, whereas the Voghji and Meghriget rivers are considered average, while all the other rivers are short.

By the level of water availability, the Vorotan and Voghji Rivers are classified as high-water/abundant rivers, and the remaining rivers are having average and low water (have flow during 3-4 months a year).

The water resources of the Southern BMA are used for drinking and municipal purposes, irrigation, industry, and power generation (Table 1.26).

Table 1.26: Classification of water resources of the Southern BMA according to the RA legislation

Name of the river	*By length*	*By feeding source*	*By significance*	*By flow*	*By annual distribution*	*By purpose of water use*
Vorotan	long	groundwater	International	high-flow	even	Irrigation, energy, fishery
Tsghuk	short	groundwater	local	medium-flow	uneven	Irrigation
Mukhuturyan	short	groundwater	local	low-flow	even	Irrigation
Sisian	short	snow melt	national	medium-flow	uneven	Irrigation, energy
Ayriget	short	mixed	local	medium-flow	uneven	Irrigation, energy
Vaghudi	short	groundwater	local	scarce	even	Irrigation, drinking-municipal
Loradzor	short	snow melt	local	medium-flow	uneven	Irrigation
Tatev	short	mixed	local	medium-flow	uneven	Irrigation
Gorisget	average	groundwater	national	medium-flow	even	Irrigation
Qashun	average	mixed	local	medium-flow	uneven	Irrigation, fishery
Shaqi	short	mixed	local	medium-flow	uneven	Irrigation, energy, fishery
Voghji	average	snow melt	International	high-flow	Sharply changing	Irrigation, energy, industry, drinking-municipal
Geghi	short	snow melt	local	medium-flow	Sharply changing	Irrigation, energy, industry, drinking-municipal
Tsav	average	mixed	International	medium-flow	uneven	Irrigation, energy
Vachagan	short	mixed	local	low-flow	Sharply changing	Irrigation, drinking-municipal
Geghanush	short	mixed	local	low-flow	Sharply changing	Irrigation
Norashenik	short	mixed	local	medium-flow	uneven	Irrigation
Meghriget	average	snow melt	International	medium-flow	uneven	Irrigation, energy
Kartchevan	short	mixed	national	low-flow	Sharply changing	Irrigation, energy
Shvanidzor	short	mixed	national	low-flow	Sharply changing	Irrigation
Shavigh	short	mixed	national	low-flow	Sharply changing	Irrigation
Nrnadzor	short	mixed	national	low-flow	Sharply changing	Irrigation
Malev	short	mixed	national	low-flow	Sharply changing	Irrigation

In terms of water quality (natural composition), waters in rivers are classified as by natural mineralization, anion and cation composition. The water quality of the rivers of the Southern BMA and their by the natural mineralization are fresh, by the anion composition -hydrocarbonated, and in the lower reaches of the Meghriget – sulphatic, by cation composition – calcic (Table 1.27).

Table1.27: Classification of water quality in the rivers of the Southern BMA Rivers according to the RA legislation

River basin	*By natural mineralization*			*By anion composition*			*By cation composition*		
	upper	*middle*	*lower*	*upper*	*middle*	*lower*	*upper*	*middle*	*lower*
Vorotan	fresh	fresh	fresh	Hydrocarbonated			Calcium	Calcium	Calcium
Voghji	fresh	fresh	fresh	Hydrocarbonated			Calcium	Calcium	Calcium
Meghriget	fresh	fresh	fresh	Hydrocarbonated		Calcium	Calcium	Calcium	Calcium

According to the RA law on National Water Program, the groundwater resources are classified according to the chemical composition and hydrogeological conditions.

According to the hydrogeological conditions, the criteria for classification of the groundwater resources are the geological structure, lithological composition, depth of the aquifers, the nature of the pressure, filtration properties of the rock and feeding conditions. Classification of the groundwater basins in Southern BMA according to the criteria is presented in the Table 1.28.

Table 1.28: Classification of the groundwater resources of the Southern BMA according to the selected parameters

River basin	***Origin and lithological composition of rocks***	***Hydrogeological parameters***			***Vulnerability of the water bodies to exogenous factors***
		Water bearing capacity of the rocks	***Depth of water bodies from the ground surface, m***	***Confining properties***	
Vorotan	Alluvial, prolluvial, fluvial lacustrine (rubble, boulder, gravel, sand, clay,)	Insignificant water bearing	< 10	unconfined	**Unprotected (extremely vulnerable)**
		water bearing	10-100	unconfined	**Insignificantly protected (insignificantly vulnerable)**
			>100	confined	**Protected (not vulnerable)**
	Volcanic (andesites, andesites and basalts, basalts and their clastolites)	Locally water bearing	10-100	unconfined	**Insignificantly protected (insignificantly vulnerable)**
		Locally water bearing	>100	Insignificantly confined	**Protected (not vulnerable)**
	Volcanogenic and sedimentary, sedimentary and intrusive rocks (tuff and sandstones, tuff conglomerates, marl, limestone, granites, diorites etc)	Locally water bearing	< 10	unconfined	**Unprotected (extremely vulnerable)**
		Locally water bearing	10-100	unconfined	**Insignificantly protected (insignificantly vulnerable)**
Voghji	Alluvial-prolluvial formation horizons in the narrow river glades (cobble, boulder, gravel, sand, clay sand)	Insignificant water bearing	< 10	unconfined	**Unprotected (extremely vulnerable)**
		water bearing	10-100	unconfined	**Insignificantly protected (insignificantly vulnerable)**
	Sediment, mainly carbonate rock complex (limestone, lime sandstone,	Locally water	10-100	confined	**Protected (not vulnerable)**

	marl)	bearing			
	Volcanic, volcanic-sedimentary rocks and intrusive complex, porphyries quartz, granite)	Locally water bearing	< 10	unconfined	**Unprotected (extremely vulnerable)**
		Locally water bearing	10-100	confined	**Protected (not vulnerable)**
Meghriget	Alluvial-prolluvial formation horizons in the narrow river glades (cobble, boulder, gravel, sand, clay sand)	water bearing	1-42	unconfined	**Unprotected (extremely vulnerable)**
	Local weak stream flow complex of intrusive rocks	Locally water bearing	85-133	confined	**Protected (not vulnerable)**
	Local stream flow zones of tectonic displacements	**Locally water bearing**	**15-20 115-130**	**confined**	**Protected (not vulnerable)**

According to the depth of location there are distinguished two main aquifers <10 m and 10-100 m (there is> 100 m deep aquifer also in Meghriget). According to the degree of vulnerability to exogenous factors, <10 m deep water horizons are highly vulnerable, and 10-100 m deep water horizons are not vulnerable (Table 1.29).

According to the chemical composition the groundwater resources are classified by:

a) General mineralization: extremely fresh, fresh and insignificantly salt-water;
b) Dominating main anion composition: hydro-carbonated and sulphic;
c) Temperature regime: into cold and lukewarm.

Classification of the groundwater resources in the river basin of the Southern BMA by chemical composition is presented in the Table 1.29.

Table 1.29: Classification of groundwater resources in the river basins of the Southern BMA by chemical composition

By the level of general mineralization				
Super fresh (up to 0.2g/l)	Fresh (0.2-1. 2g/l)	Insignificantly salty (1-3 2g/l)	Salty (3-35 2g/l)	Salt-water (35 2g/l and more)
+	+	+	NA	NA
Connected eluvial-deluvial, fluvial-glacial formations, at altitudes 2350 meters and over and the mineralization of waters is 0.18-0.19 g/l. Super fresh waters are also common for Syunik plateau (Gorhayk, Angeghakot, Mukhuturyan etc.) volcanic rocks.	At the altitudes of 1200-2900 m there are dominating with general mineralization of 0.2-0.4 g/l, and up to 1200 m altitudes - 0.4-0.5 g/l and more. Alluvial-prolluvial ground water horizons - 0,5-0,8 /l, n the fracture water of the intrusive rocks- 0,35-0,6 l.	2.6 mg / l mineralization mineral waters were found in the northern outskirts of the village Vanek (Norashenik river basin). Horizon of mineral water from the displacement of tectonic zones (1.7 g / l) nearby Shvanidzor village. In the quartzenated, silicated, basalt porphyries of the gorges of intermountain depressions of transformed mid flow of Vorotan river basin.	NA	NA
By the domination anions in the chemical composition				
Hydrocarbonate, HCO_3^-	Sulphate, SO_4^{2-}		Clorine, Cl^-	
+	+		-	
In all absolute elevations the underground water contains dominating hydrocarbon ion, rarer - sulphic	Connected with the tectonic zones the composition of the mineral water is sometimes dominated by sulphate natrium ions		-	
By temperature regime				
Up to 20^{0}C	Lukewarm 20-40^{0}C		Warm 40-100^{0}C	Super warm, over 100^{0}C
+	+		NA	NA

Water in the volcanic rocks of Vorotan river basin is -13^{0}C, at the river basin of Voghji at the elevation of 2900-3000 m and higher – up to 4-5^{0}C, at the elevations of 1200-2900 m - 6-10^{0}C, and 10-13^{0}C before the elevation of 1200 m. In the water bearing horizons of fractured rocks of Meghriget river basin water is 8-12^{0}C Ł, in the of alluvial-prolluvial water bearing horizons - 12-16^{0}C, and 13-20^{0}C in the mineral water..	22-35^{0}C water is common for the transformed quartzenated, silicate, basalt porphyries of Vorotan river basin	-	-

1.2.5. *Usable Water Resources, Strategic and National Water Reserves in the Southern BMA*

Volumes of the usable water resources, strategic and national water reserves in the southern BMA are determined in accordance with the requirements of the RA Law on National Water Program. All the values are provided on average annual basis.

The usable surface water resources are calculated by the difference between the natural river natural flow and ecological flow. Usable groundwater resources are A + B approved volumes of operational groundwater resources.

The multi-annual average values of usable surface water and groundwater resources in the Vorotan, Voghji and Meghriget River Basins of Southern BMA are presented in Table 1.30.

The volume of the strategic water reserve was calculated as a sum of the 2/3rd of total volume of lakes to be used, dead storage of the reservoirs and the average annual drainage flow of the groundwater resources (C_1 class operational reserves). The strategic water reserve of the Southern BMA is 203.6 million m^3, with the Vorotan River Basin having the largest share - 148.5 million m^3 (Table 1.30).

The national water reserve is formed by the 1/3rd of total volume of lakes and the dead storage of reservoirs and the deep flow (which is the difference between usable and strategic groundwater resources), as well as the volume of the snow and firn zones. The national water reserve for the Southern BMA is approximately 356 million m^3 (Table 1.30).

Table 1.30: Usable water resources, strategic and national water reserves in the Southern BMA

Water resource in the river basin, million m^3	**River basin**		
	Vorotan	**Voghji**	**Meghriget**
Usable water resources	**618.9**	**393.9**	**138.0**
River flow	556.8	321.7	109.65
Operational reserves of groundwater approved by the classes A+B, average annual discharge of the springs	62.1	72.2	28.35
Total	**1150.1**		
Strategic water reserve	**148.5**	**29,06**	**26,03**
30% of total volume of natural lakes	4.0	0,221	0,2
2/3 of the dead storage of reservoirs	23.1	2,34	-
Operational reserves of groundwater approved by the class C1	121.4	26,5	25,83
Total	**203.6**		
National water reserve	**262.0**	**88,58**	**5,39**
1/3 of volume of natural lakes	4.4	0,52	0,06
1/3 of the dead storage of reservoirs	11.6	1,16	-
Snow and firn zones	-	0,5	0,3
Deep flow	246.0	86,4	5,03
Total	**356.0**		

1.2.6. Hydropower Potential of the Rivers in the Southern BMA

According to the Final Report on Updating the Existing Scheme for Small Hydropower Plants in the Republic of Armenia, provided by the RA Ministry of Energy and Natural Resources and developed by Hydroenergonakhagits CJSC in 2008, within the framework of the Renewable Energy Project of the Renewable Energy and Energy Efficiency Fund, the hydropower potential of the Vorotan River Basin is estimated at 400 MW. As of 2013, the Vorotan HPP Complex with its large-scale 3 HPPs was operating in the Vorotan River Basin, with capacity of 405.5 MW and 1160 million kWh of electricity production. There were also 25 small HPPs (SHPPs) with 15.4 MW total capacity and 69.34 million kWh of annual average production. As of January 2013, 12 SHPPs with total capacity of 19.1 MW were under construction. The total capacity of the Vorotan River Basin hydropower plants and small hydropower plants was 440 MW, which exceeds the estimated hydropower potential of the river basin. That is explained by operation of 4 major reservoirs.

The hydropower potential of the Voghji and Tsav Rivers and their tributaries is estimated at 53 MW, 463 million kWh of electricity production. As of January 2014, 19.7 MW of potential was used by SHPPs in the Voghji River Basin. In the same period, there were small hydropower plants under construction with total capacity of 15.5 MW, with the total output reaching 110.1 million kWh. After the operation of the small hydropower plants under construction, 66% of total estimated hydropower potential of Voghji River will be used.

In the Meghriget River Basin, hydropower potential was estimated for the Meghriget and Karchevan Rivers only. The hydropower potential of the small rivers discharging into the Araks River was not calculated, due to the temporary flow of the rivers. The hydropower potential of the Meghriget and Karchevan Rivers is estimated at 40.5 MW, 353 million kWh of electricity production. As of 2014, the use of the basin's hydropower potential through hydropower plants amounted to 6.77 MW. There were also SHPPs under construction with a total capacity of 6.52 MW with a total output of 44.8 million kWh. About 32% of hydropower potential of the river basin would be used after operation of SHPPs which are under construction.

The hydropower potential of the Southern BMA is estimated at approximately 494 MW, out of which only 449 MW is used, i.e. 1460 million kWh.

1.3. Strategy for Ensuring Water Supply/Availability in the Southern BMA

Nine reservoirs that were operating in the Southern BMA as of January 2014 were mainly used in industry, including hydropower generation, irrigation and fish farming. The reservoirs are mainly located in the middle and lower streams of the rivers. Most of the reservoirs are located above the arable lands, thus mechanically irrigating the croplands.

According to the Concept Paper for Perspective Program on Reservoir Construction, 8 reservoirs are planned to be constructed in the Vorotan River Basin, with total 33.6 million m^3 designed capacity, and feasibility studies to be conducted for additional 6 reservoirs with about 100 million m^3 designed capacity (Table 1.31).

There are 2 reservoirs currently being designed in the Voghji River Basin, with 18.25 million m^3 designed capacity. Six other reservoirs with approximately 55.68 million m^3 designed capacity must still be studied and designed (Table 1.31).

It is planned to construct 2 reservoirs in the Meghriget River basin with about 5.30 million m^3 designed capacity, study 7 reservoir basins with about 6.04 million m^3 designed capacity, as well as to build 1 reservoir with 0.50 million m^3 reservoir, which yet to be explored (Table 1.31).

Table 1.31: List of planned and designed reservoirs in the Southern BMA

No.	Reservoir name	Location	Capacity, mln. m^3	Status
Vorotan river basin				
1	Mukhuturyan	In the middle streams of the Mukhuturyan River	2.5	Designed
2	Arigli	On the Arigli River, south-west of the Shaghat village	5.5	Planned
3	Tasik	On the Sisian River, south-west of the Tasik village	11	Planned
4	Tatev	On the Tatev River, west of the Tatev village	1.8	Planned
5	Goris	On the Vararakn River, in the Akner village	11	Planned
6	Bayandur (Vaghatur)	On the Bayandur River, west the Vaghatur village	0.45	Planned
7	Khoznavar	On the Khoznavar River, west of the Khoznavar village	0.36	Planned
8	Lernashen	On the Arigil River, south-west of the Shaghat village	1	Planned
Voghji river basin				
1	Tsav	In the middle streams of the Tsav River	1.25	Under design
2	Norashenik	On the Norashenik River, near the Arajadzor settlement	17.0	Under design
3	Voghji-1	Upper stream of the Voghji River	13.0	Planned
4	Voghji -2	Middle stream of the Voghji River	10.86	Planned
5	Artsvanik	On the Artsvanik River	15.18	Planned
6	Kahudi	On the Geghi River, near the settlement of Getashen	3.6	Planned
7	Kachaghar	In the Voghji River Basin	8.04	Planned
8	Geghanush	Middle stream of the Geghanush River	5.0	Planned
Meghriget river basin				
1	Lichk	Upstream of the Meghriget River, above Lichk settlement	3.80	Designed
2	Gyolji		1.50	Designed
3	Boghaqar	On the Bughakar tributary of the Meghriget River	1.30	Planned, explored
4	Tashtun	On the Tashtun tributary of the Meghriget River	0.67	Planned, explored
5	Vahravar	On the Vahravar River, above Vahravar settlement	0.90	Planned, explored
6	Vanq	Above Vank settlement	0.92	Planned, explored
7	Shvanidzor	Upstream of the Meghriget River, above Lichk village	3.80	Designed
8	Aldaray		1.50	Designed
9	Nyuvad	On the Bughakar tributary of the Meghriget River	1.30	Planned, explored
10	Meghri	On the Tashtun tributary of the Meghriget River	0.67	Planned, explored

Source: Concept Paper for Perspective Program on Reservoir Construction, RA Law on National Water Program

Implementation of the concept paper will create additional storage capacity of about 219.4 million m^3 of water in the Southern BMA, which in turn will increase the water flow regulation capabilities and solve a number of strategic issues.

1.4. Quality of Water Resources

The description of quality of water resources in the rivers of the Southern BMA was made based on the data provided by the EIMS and Hydrogeological Monitoring SNCOs of the RA MNP.

1.4.1. Quality of Surface Water Resources

Monitoring of surface water resources in the Southern BMA is conducted by the EIMC SCNO under the RA MNP in 21 sampling points. According to the monitoring data for 2007-2013, the quality of waters in the rivers of the Southern BMA are of hydrocarbonate-calcium nature, with low or moderate mineralization, characterized by weak alkaline water environment and low hardness (the Gorisget Voghji, Artsvanik and Geghi Rivers have specific average water hardness). Content of suspended solids in the rivers varies based on seasonality.

According to the monitoring data, the oxygen regime in the rivers of the Southern BMA is satisfactory along the entire length of the rivers for sustaining of aquatic ecosystems, except the Artsvanik and Karchevan Rivers, where critical lack of oxygen was observed. High values of elements of the oxygen regime indicate the high levels of organic pollutants in the waters of the Artsvanik and Karchevan Rivers.

According to monitoring data, concentrations of elements of oxygen and nutrients, as well as heavy metals are increasing gradually in the lower reaches of rivers of the Southern BMA, particularly in the Voghji and Meghriget River basins. During the observed period, in the middle and lower reaches, hydrochemical indicators were permanently high and stable, which is a proof of the continued pollution of rivers. Waters of the rivers in the Southern BMA are polluted by the return flows from agriculture, residential areas both point and diffuse sources of pollution, as well as surface runoff from the mines and tailings dams.

Such pollution of waters leads to intensification of the eutrophication processes, while pollution by heavy metals leads to contamination of waters and ecosystems degradation. As a result, biodiversity in the lower reaches of the Karchevan and Artsvanik Rivers has disappeared.

1.4.2. Quality of Groundwater Resources

The Hydrogeological Monitoring Center under the RA MNP is conducting monitoring of the groundwater quality in the Southern BMA in 7 points in the Vorotan River Basin. There is no groundwater quality monitoring in the Voghji and Meghriget River Basins.
During 2009-2013, groundwater resources in the Vorotan River Basin were monitored twice a year, in spring and autumn. About 20-24 indicators were analyzed in the samples collected from groundwater resource: generalized chemical indicators, biogenic elements, some metals and organic pollutants.

According to the monitoring data for 2009-2013, groundwater sources in the Sisian and Gris regions of the Vorotan River Basin are hydrocarbonate nature, except the Shaqi source where low level of sulphate was detected. The groundwater resources are having neutral environment, weak hardness and weak mineralization. In general, according to the WFD requirements, the groundwater resources in the Vorotan River Basin by their chemical composition correspond to Good and Excellent quality classes as defined by the EU WFD.

According to expert assessment, the quality of groundwater resources in the Voghji and Meghriget River Basins are vulnerable due to open mines and tailings dams. It is necessary to develop and implement a new groundwater monitoring program in these river basins.

1.5. Organization of Water Resources Monitoring in the Southern BMA

Monitoring of quantity and regime of the surface water resources in the RA is conducted by the Armenian State Hydrometeorological and Monitoring Service under the RA MTAES. According to the structure of hydrological monitoring network, the hydrological observation points of the Southern BMA are serviced by the Goris hydrological station. Twenty two hydrological observation points have been operational in the basin during various years, out which only were 10 were operational in 2014 (Table 1.32 and Figure 1.12).

Table 1.32: Hydrological observation points in the Southern BMA

No.	*River-hydrological observation point*	*Catchment area, km^2*	*Operation period*		*Altitude of the observation point, m.a.s.l.*
			Opening date	*Closing date*	
1	Vorotan-Gorhayk	268	09.1988	In operation	2075
2	Vorotan-Borisovka	507	05.1942	04.1988	-
3	Vorotan-Angeghakot	643	01.1965	07.1994	-

No.	River-hydrological observation point	Catchment area, km^2	Operation period		Altitude of the observation point, m.a.s.l.
			Opening date	Closing date	
4	Vorotan- Vorotan	1550	06.1951	In operation	1395
5	Vorotan-Tatev HPP	1988	01.1968	In operation	722
6	Daliget- Borisovka (Tsghuk- Tsghuk)	136	01.1950	12.1987	-
7	Tsghuk- Tsghuk	85	01.1988	In operation	2066
8	Sisian-Arevis	118	01.1963	01.1988	-
9	Sisian -Ashotavan	204	11.1978	03.1994	-
10	Vaghudi- Vaghudi (Vaghatin)	30,4	01.1977	10.1988	-
11	Loradzor-Ltsen	118	01.1934	12.1981	-
12	Tatev - Tatev	84,2	01.1960	07.1988	-
13	Gorisget-Goris	65	07.1967	In operation	1424
14	Voghji-Kajaran	120	02.1959	In operation	1768
15	Voghji -Kapan	710	07.1929	In operation	755
16	Geghi- Geghi	195	09.1958	01.1988	-
17	Geghi -Kavtchut	272	01.1950	In operation	1272
18	Norashenik- Norashenik	96,0	01.1947	12.1970	-
19	Vachagan- Kapan	35,0	01.1965	In operation	801
20	Geghanush- Geghanush	44,8	04.1961	12.1987	-
21	Meghriget-Litchk	21,0	01.1946	01.2002	-
22	Meghriget - Meghri	274,0	01.1945	In operation	630
23	Kartchevan-Agarak	19,0	01.1970	01.1974	-
24	Astazurget-Shvanidzor	32,5	04.1966	12.1978	-

Source: Armenian State Hydrometeorological and Monitoring Service under the RA MTAES

The surface water quality in the Southern BMA is monitored by the EIMC SNCO of the RA MNP. As of January 2014, there were 21 sampling points surface water quality monitoring in the Southern BMA located in the Vorotan, Sisian, Gorisget Voghji, Artsvanik, Geghi, Meghriget and Karchevan rivers (Table 1.33 and Figure 1.12). Surface water quality during 2007-2013 was monitored 11-12 times annually, one time each month. The oxygen, mineralization and nutritional regime were analyzed, as well as 42-68 hydrochemical, including heavy metals, primary and secondary organic pollutants.

Table 1.33: Surface water quality sampling points in the Southern BMA

No. of sampling point		River	Location of the sampling point	Coordinates		Operation period	
				Latitude	Longitude	Opened	Closed
1	99	Vorotan	0.5 km upstream the Gorhayk village	39^o 56'43,1''	44^o 52'13,6''	07.1989	In operation
2	238	Vorotan	1.8 km upstream the Angeghakot village	-	-	02.1977/ 04.2011	08.1988/ 04.2012
3	100	Vorotan	1 km upstream the Sisian town	39^o 32'45,9''	46^o 00'22,5''	03.1982	In operation
4	101	Vorotan	2 km downstream the Sisian town	39^o 30'45,7''	46^o 02'43,7''	03.1982	In operation
5	102	Vorotan	In the Vorotan community (Tatev HPP)	39^o25'36,1''	46^o 22'22,2''	03.1982	In operation
6	103	Sisian	0.5 km upstream the Arevis village	39^o24'06,6''	45^o 53'57,2''	04.1980	In operation
7	104	Sisian	Tolors reservoir	39^o26'06,6''	45^o 53'57,1''	04.1993	In operation
8	236	Ayriget	0.4 km upstream the Dastakert	-	-	02.1977/ 04.2011	03.1991/ 04.2012
9	237	Ayriget	1.6 km downstream the Dastakert	-	-	02.1977/ 04.2011	03.1991/ 04.201.
10	105	Tatev	1.5 km downstream the	-	-	03.1982	01.1991

No. of sampling point		River	Location of the sampling point	Coordinates		Operation period	
				Latitude	Longitude	Opened	Closed
			Tatev				
11	106	Goris	3 km upstream the Goris town	39° 32'41,9''	46° 18'42,9''	02.1977	In operation
12	107	Goris	1 km downstream the Goris town	39 ° 29'06,9''	46° 21 '26,6''	02.1977	In operation
13	91	Voghji	1.7 km upstream the Kajaran town	39° 09′ 00.4″	46° 9′ 16.6″	02.1977	In operation
14	92	Voghji	1.8 km downstream the Kajaran town	39° 09′ 04.5′′	46° 11′51.5″	02.1977	In operation
15	93	Voghji	0.8 km upstream the Kapan town	39° 12′ 43.5′′	46° 22′32.6″	02.1977	In operation
16	321	Voghji	Near Kapan airport	-	-	06.2005	In operation
17	94	Voghji	6.8 km downstream the Kapan town	39° 12′ 04.6′′	46° 26′34.1″	02.1977	In operation
18	95	Artsvanik	0.5 km upstream the tailing dam	39° 16′ 35.6′′	46° 27′02.1″	01.1993	In operation
19	96	Artsvanik	Near the river mouth	39° 12′ 09.6′′	46° 27′58.0″	01.1993	In operation
20	97	Geghi	0.5 km upstream the Ajabaj village	39° 15′ 13.8′′	46° 04′ 18.4″	01.1993	In operation
21	98	Geghi	Near the river mouth	39° 11′ 49.6′′	46° 15′39.3″	02.1977	In operation
22	322	Vachagan	In the Kapan town	-	-	03.2006	07.2006
23	326	Tsav	Near the Tsav village	-	-	05.2006	06.2006
24	235	Meghriget	Near the Lichk village	39° 03′ 13′′	46° 10′ 33′′	02.1982	In operation
25	89	Meghriget	0.5 km upstream the Meghri town	38° 54′ 56′′	46° 14′ 16′′	01.1993	In operation
26	90	Meghriget	Near the river mouth	39° 53′ 43′′	46° 15′ 42′′	02.1977	In operation
27	344	Karchevan	Near the river mouth	38° 51′ 30′′	46° 12′ 48′′	03.2010	In operation

Source: EIMC SNCO under the RA MNP

The groundwater resources in the Southern BMA are monitored by the Hydrogeological Monitoring Center SNCO under the RA MNP. As of January 2014, hydrogeological monitoring was carried out on 9 water sources, including 7 points in the Vorotan River Basin (in the area between the settlements of Shaqi - Gorhayk), and 2 in the Gorisget River Basin (Table 1.34, Figure 1.12).

Groundwater springs discharge, level and temperature are monitored 6 times per month, while chemical analysis for determining the total level of mineralization is conducted twice in a year.

Table 1.34: The groundwater resources monitoring network in the Southern BMA

No. of the post	Location	Monitoring point			Coordinates	
		Type	Average annual discharge (l/sec)	Altitude, m.a.s.l.	Latitude	Longitude
Sisian region						
529	v. Gorhayk	Spring	7.6	2070	39°41'54,26"	45°46'6,86"
537	v. Spandaryan	Spring	4.5	1995	39°37'53,11"	45°54'6,90"
532	v. Shaqi	Spring	1198.5	1702	39°33'52,47"	46° 0'0,94"
1175	v. Angeghakot	Spring	5.5	1751	39°34'23,93"	45°56'18,42"
1322	v. Angeghakot	Spring	4	1714	39°34'23,24"	45°56'25,85"
1318	v. Angeghakot	Spring	6.6	1690	39°34'22,51"	45°56'31,73"
1323	v. Angeghakot	Spring	1.3	1514	39°34'20,39"	45°56'32,95"
Goris region						
899	t. Goris	Spring	0.47	1348	39°30'36,81"	46°21'5,75"
1399	t. Goris	Spring	5.5	1470	39°30'25,63"	46°21'26,23"

Source: Hydrogeological Monitoring Center under the RA MNP

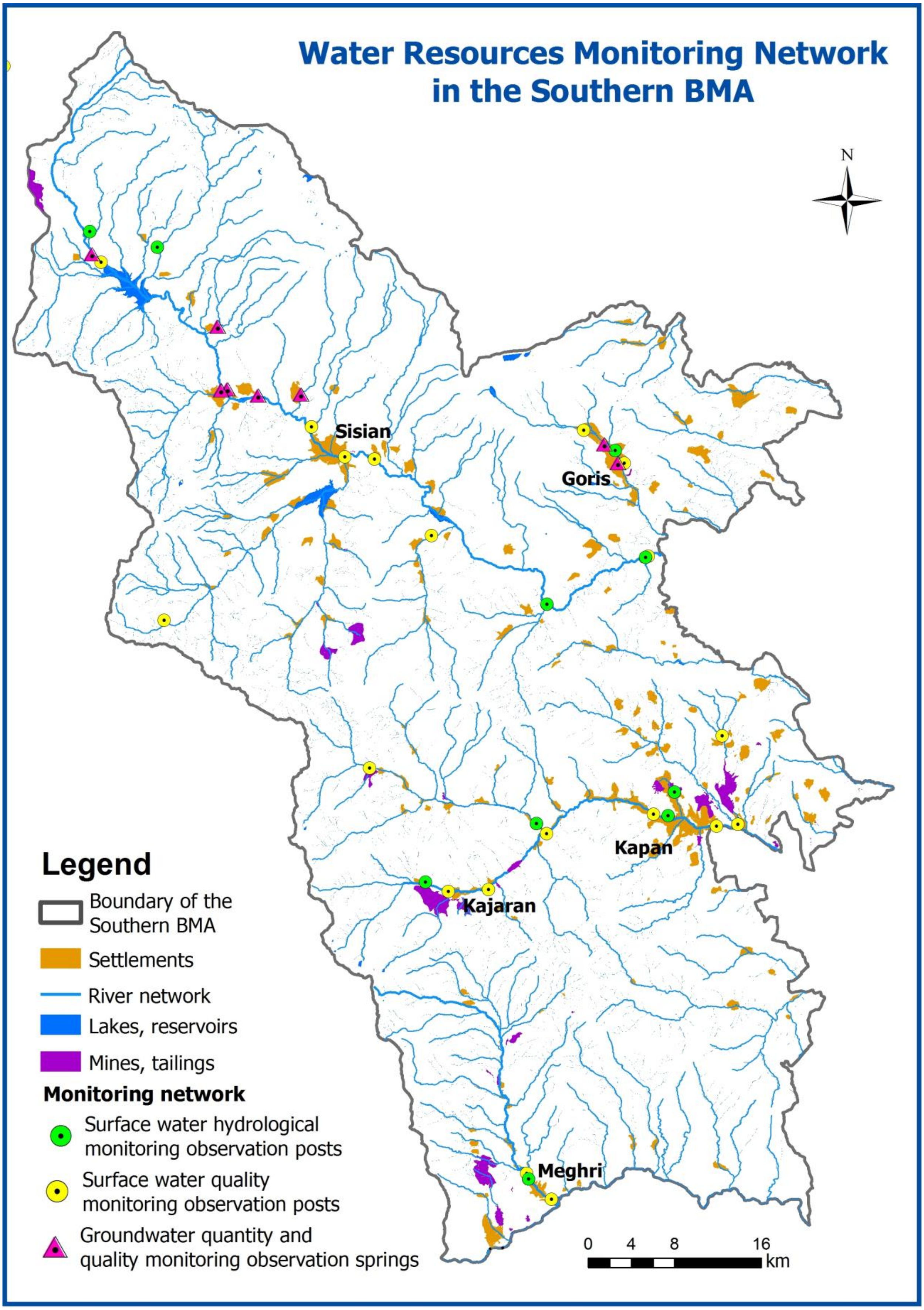


Figure 1.12: Water resource monitoring network of the Southern BMA

Source: EIMC and Hydrogeological Monitoring Center SNCOs under the RA MNP, Armenian State Hydrometeorological and Monitoring Service under the RA MTAES (system of coordinates WGS, UTM Zone 38N)

1.6. Description of Water Resources, in terms of Safety

The fundamental provisions on safe use of water resources in the Republic of Armenia are specified in the RA Water Code and a number of water related regulatory acts. Water use is carried out through hydrotechnical structures (HTS). The Government of Armenia bears the responsibility for reliable and safe use of state-owned hydrotechnical structures, and the owner himself for private ones.

Below are the key safety indicators for sustainable and reliable operation of HTSs, and assessment and reduction of risks:

- Ensuring of unimpeded flow of estimated maximum discharge through drainage structures of the hydrotechnical unit;
- Furnishing the hydrotechnical unit with measuring, controlling equipment, and communication means;
- Presence of safety declarations and a guarding service;
- Measures implemented for protection of the sanitary zone;
- Availability of an alternative (back-up) source of power supply;
- Presence of a reserve pump at mechanical systems of drinking and irrigation water supply;
- Unacceptability of outside buildings and structures in the alienation zone of the hydro technical unit;
- Fire protection measures are in place;
- Ensuring of drinking and irrigation water quality;
- Prevention of causes of formation of wetlands, water losses, and backwater occurrences in the surroundings of the hydrotechnical unit;
- Ensuring of sediment load accumulation, removal and washing practices;
- Ensuring of impermeability and durability of confined aquifers, as well as solidity of their adjustable pillars;
- Presence of ventilation shafts in tunnels and their operability;
- Presence of structures prohibiting unauthorized access to alienation zones of HTSs.

The HTSs of special state significance in the Southern BMA are presented below:

- The Spandaryan, Angeghakot, Tolors, Davit-Bek and Geghi Reservoirs;
- The Vorotan-Arpa-Sevan tunnel;
- Canals used for irrigation and hydropower generation purposes with 5 m^3/s capacity, including canals of the Vorotan HPP Complex and Vorotan irrigation canals;
- The Geghi-Yeghvard irrigation canal;
- Daily regulation reservoirs for water supply for the Kapan, Goris, Sisian, Kajaran and Meghri towns;
- Special groundwater and other water intake structures used for water supply that are protected by the State.

All other HTSs in the Southern BMA are of significance.

Safety arrangements for the HTS' are the following

- Filed safety declaration;
- Procedure of authorizing operation of the system;
- Ensuring of uninterrupted operation;
- Safety measures, including: (a) establishment of safety criteria; (b) equipping HTSs with technologies which allow for permanent control of their technical state; and (c) recruitment of a competent staff for HTS operation;
- Preliminary complex measures within HTSs, which contribute to possible reduction of potential emergency situations;
- Individual accountability for the actions that have reduced HTSs safety levels below permissible.

CHAPTER 2: IDENTIFICATION OF CURRENT AND DESIRED CONDITIONS AND FUNCTIONS OF WATER USE IN THE SOUTHERN BASIN MANAGEMENT AREA

2.1. Identification of Current and Desired Conditions and Functions for Water Use

2.1.1. Legal and Institutional Framework of the Water Sector

Legal framework: The adoption of Water Code of Armenia on June 4, 2002 is one of the most important steps in water sector reforms. The Water Code provides concepts of integrated management of water resources at the basin level, promotes decision-making process on allocation of water resources based on water supply/availability and not demand, serves a basis for establishment of state water cadastre, requests information-based issuance of water use permits and provides opportunity for management of water resources with application of economic instruments.

In order to provide the enforcement of the Water Code of Armenia, over 80 normative acts on procedures of issuing water use permits, river basin management, transparency and public participation in decision-making process, information accessibility, establishment and maintenance of the state water cadastre and provision of information upon request, management of transboundary water resources and other issues have been adopted in Armenia since 2002.

The RA Law on Fundamental Provisions of the National Water Policy was adopted in 2005, which is a long-term development concept for strategic use and protection of water resources and water systems.

The RA Law on the National Water Program was adopted in 2006, targeted at development of measures for satisfying the needs of the population and economy, ensuring ecological sustainability, formation and use of strategic water reserve, and protection of the national water reserve. Short- (up to 2010), medium- (2010-2015) and long-term (2015-2021) programs were developed aimed at implementation of objectives of the National Water Program.

Requirements for preparation of the basin management plans were stipulated by the Protocol Decision of the RA Government No. 4 on the Outline of the Model River Basin Management Plan, dated 03.02.2011.

The Republic of Armenia actively participates in the international cooperation processes, a number of international and European environmental conventions and protocols deriving there from have been signed and ratified. Armenia aims at preventing or restricting the harmful impact on the human health and the environment, eliminating excessive air pollution, mitigating the negative impacts of global climate change, conserving biodiversity, ensuring required reproduction volumes of renewable natural resources and conditions ensuring the natural balance, as well as providing rational and efficient use of non-renewable natural resources within the frames of the commitments.

Institutional framework: The concept of institutional reforms in the water sector of Armenia was established through the RA Government Decision on Concept of Water Sector Reforms of Armenia, adopted in February, 2001, which served a basis for the institutional framework set in the Water Code.

In order to promote a more effective, targeted and decentralized management of water resources, 6 territorial divisions, including Northern, Akhuryan, Ararat, Sevan, Hrazdan and Southern Basin Management Organizations (BMOs) within the structure of the Water Resources Management Agency of the RA Ministry of Nature Protection have been established.

BMOs, according to their charters, are responsible for development and implementation of water basin management plans, development of long-term designs and projects for water resources management, use and protection based on basin characteristics and specific issues, accepting applications for water use permits, registration and submission of the permit applications to the WRMA, registration of the water use permits issued by WRMA in special registries, supervision and control of conditions stipulated by water use permits, community outreach and etc.

Water sector is governed by authorities presented in Table 2.1.

Table 2.1: Main functions of water sector management authorities

Sector	Management and protection of water resources	Licensing and Tariff regulation	Management of water systems
Authorized body	Water Resources Management Agency within the structure of Ministry of Nature Protection	Public Services Regulatory Commission	State Committee of Water Systems within the structure of the Ministry of Agriculture
Main functions	Strategic management and protection of water resources, assessment and allocation of water resources	Tariff regulation for non-competitive drinking, household and irrigation water supply and sanitation service provision, protection of consumer rights License issuance	Management of state-owned water systems, support for the establishment of WUAs and unions, organization of tenders for organizing management of water systems
Enforcement mechanisms	Water use permits	Water systems use permits, Licenses	Management contracts

The following structural units are primarily related to water sector management in the Southern BMA:

1) Department of Agriculture and Environment of Syunik marz Administration of the Republic of Armenia;
2) Syunik territorial division of the State Environmental Inspectorate of the Ministry of Nature Protection of the Republic of Armenia;
3) Southern BMO of the staff of the WRMA under the Ministry of Nature Protection of the Republic of Armenia;
4) NGOs dealing with environmental issues, Marz Aarhus Centers;
5) Specially protected nature areas located in the Marz, including Shikahogh State Reserve, Arevik National Park, Boghakar, Goris, Sev Lich, Plane Grove and Zangezur Sanctuaries.

According to RA President Decree on Public Administration in Marzes of Armenia from May 6, 1997, the powers of the Marz Governor in the field of nature and environment protection are as follows: Marz Governor (1) participates in the development of nature and environment protection state programs and ensures their implementation in the Marz territory; (2) controls the implementation of environmental legislation and informs the relevant authorities regarding documented violations; (3) supports the protection and use of state reserves, state sanctuaries and specially protected areas and implements measures addressing poaching, illegal fishing and logging; (4) cooperates with non-governmental organizations and citizens engaged in environmental issues.

According to the law of the Republic of Armenia on Local Self-Government adopted in 2002, the chief of the community is responsible for the following, as prescribed by the law or by government: (1) conducting an environmental inventory of the community; (2) in the sphere of nature and environmental protection, organizing the maintenance of lands, forests and water reserves that are property of the community, as well as environmental protection; (3) carrying out supervision in the sphere of nature protection; (4) organizing the use and protection of entrails, forest, water areas, atmosphere, flora and fauna; and (5) ensuring the protection of lands from sliding, flooding, water logging, and pollution by chemicals and radioactive agents and industrial waste.

2.1.2. Landscape and Land Use

The data introduced in this section are based on the materials provided by the RA Ministry of Agriculture and Syunik marz Administration, as well as results of land use classification implemented by remote sensing of high-resolution satellite images within the framework of USAID Clean Energy and Water Program (CEWP).

Land fund by function of the land and type of ownership: According to land use classification using high-resolution satellite images within the framework of CEWP, the land fund of the Southern BMA in January of 2014 comprised 449817 ha, which is mostly composed of agricultural lands (67.8%), lands under specially protected areas of nature (14.3%) and forest lands (13.4%). The rest of the land fund (4.5%) is represented by such lands under settlements; industrial, urban fabric other lands (Figure 2.1).

According to the data acquired from Syunik marz Administration, as of 2014, state owned lands constituted 22.4%, 74.5% were under community ownership and 3.1% belonged to legal persons at the Southern BMA.

Assessment of land use: As of 2014, the largest share of land constituted agricultural lands, forestland and bushes, which represented about 95.46% of the Southern BMA. The share of land use in other sectors was insignificant constituting about 5% of the Marz territory. For example land use for industrial purposes made only 1.19%, and urban development 2.29% (Table 2.2, Figure 2.1).

Table 2.2: Land use in the Southern BMA as of 2014, ha

Urban fabric	Industrial, commercial and transport units facilities	Mines, tailing dumps, construction sites	Artificial non-agricultural vegetated areas	Arable land	Permanent crops	Pasture, grasslands	Heterogeneous agricultural lands	Open spaces with little or no vegetation	Forests	Shrubs, bushes	Inland wetlands	Water bodies	Total
				Agricultural lands									
10319	2382	2836	19	34708	287	223458	809	45725	71068	53352	23	4831	**449817**

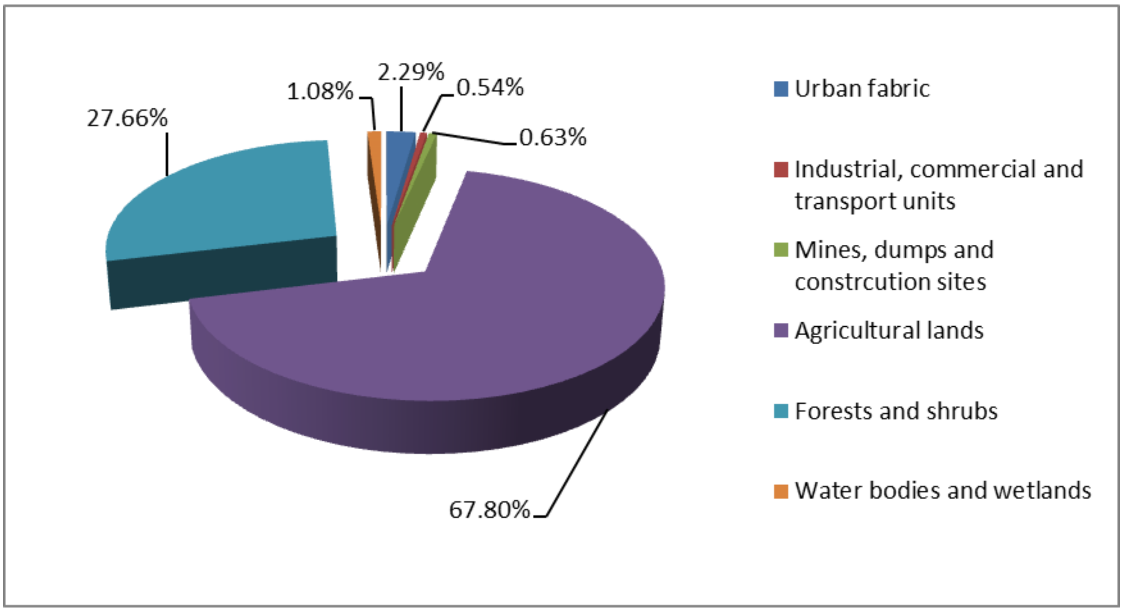


Figure 2.1 Land use in the Southern BMA, %
Source: USAID Clean Energy and Water Program, 2014

For the same period, more than the half of agricultural lands (73.27%) in the Southern BMA was pastures and grasslands. Pastures are located at 1000 m and higher altitudes. Open spaces with little or no vegetation composed 15% of the Southern BMA, while arable lands made up about 11.4% covering middle and lower reaches of the rivers and intermountain trough areas. Some part of the arable lands was terraced due to high declivity. Permanent crops had a very small share of agricultural lands, comprising 0.09% (Figure2.2).

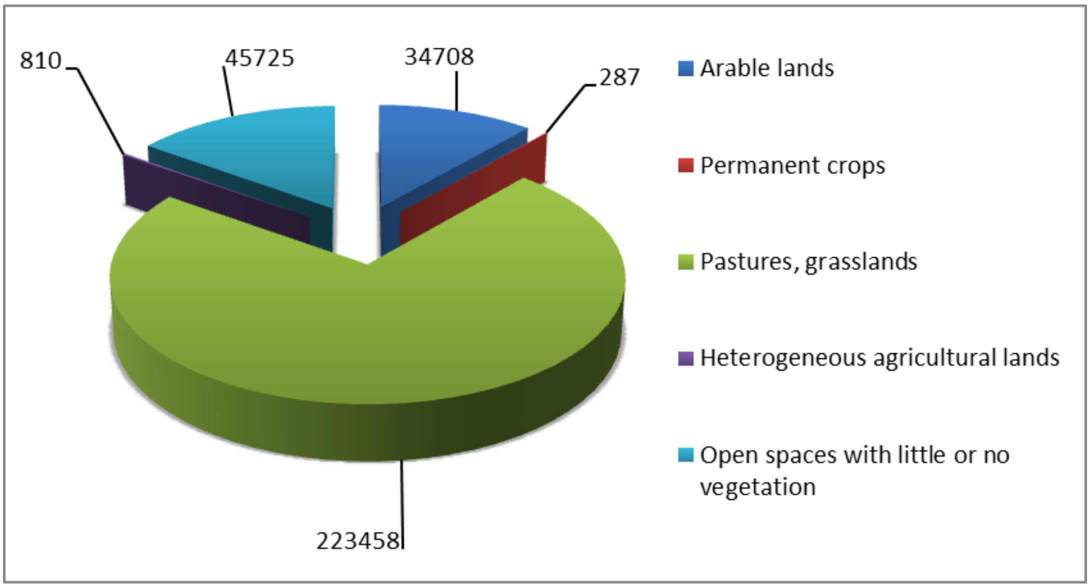


Figure 2.2 Agricultural lands in the Southern BMA, ha
Source: USAID Clean Energy and Water Program, 2014

About 38% of agricultural lands in the Southern basin are located on areas with slopes of 0-15° gradient, which are considered suitable of agricultural practices. About 47% of lands are distributed on areas of limited usability (15-25 ° gradient), while the remaining 15% are rendered to be useless lands, rocks and cliffs.

About 35750 ha of the Southern BMA were cultivated in 2013, with the prevailing share 67% being taken by cereals. The remaining irrigated lands were used for cultivation of technical crops and vegetables. Orchards are very limited in the Southern BMA (0.34 %).

Use of forests and other landscape types: As of 2014, forests and bushes occupied about 28% of the Southern (BMA 124420 ha). Forests are primarily located at the middle and lower reaches of the Vorotan, Voghji and Meghriget Rivers, Qashun and Tsav River Basins, as well as at the middle and upper reaches of small tributaries to the Araks River.

Predominating tree species occurring at the Vorotan and Voghji River Basins include Eastern oak and hornbeam, with some occurrence of oriental hornbeam, beech, lime, ash, maple, as well as wild pear, apple tree species. Lower and middle forest belts of the Meghriget River Basin are characterized with sparse forests with juniper tree being the predominating species. Bushes observed in the river basin are represented by cornelian cherry, medlar, wayfaring tree, etc. There are some islets of planted pines trees in the forests.

Only a small portion of extensive grasslands of the Southern basin is currently use, especially those that are on elevations above 2500 m. This is conditioned by sparse population and small quantity of livestock.

2.2. Water Use in the Southern Basin Management Area

Water use in the Southern BMA in 2014 was analyzed based on data provided by the WRMA of the RA MNP, while characteristics of hydrotechnical structures (HTS) were presented based on data and information provided by the SCWS of the RA Ministry of Agriculture and Ministry of Energy and Natural Resources.

2.2.1. Water Use

According to water use permits data provided by the WRMA of the RA MNP, as of January 2014, main water users of Southern BMA were hydropower generation, irrigation, and drinking-household and industry sectors (Table 2.3). Major part of water used for hydropower generation took place in the Vorotan River Basin by Vorotan HPP complex, and for industrial purposes - in the Voghji River Basin (Dundee Precious Metals CJSC and Zangezur Copper-Molybdenum Combine).

Water abstraction for use in the Southern BMA was done from surface water (about 97.5% of total water use) and groundwater resources (2.5%).

Table 2.3: Water use in the Southern BMA by sectors, as of 2014, thousand m^3

River basin	*Total water abstraction*	*Water use by sectors*					
		Drinking-household	*Irrigation*	*Industry*	*Fish production*	*Hydropower generation*	*Livestock watering*
Vorotan	**1948573.71**	30283.87	32231.22	265.42	17259.85	1868143.05	140.05
Voghji	**577718.96**	21396.48	4060.49	65341.75	1339.49	485831.00	0
Meghriget	**121419.77**	5821.79	10 441.6	13880.68	0	91275.70	0
Southern BMA	**2647712.45**	***57502.15***	***46733.31***	***79487.85***	***18 599.34***	***2445249.75***	***140.05***

Source: WRMA of the RA MNP

As of January 2014, main water use of the Southern BMA was for hydropower generation, comprising about 92.35% of the total water use (Figure 2.5). Water use for industrial purposes constituted 3.0%, irrigation purposes - 1.77%, drinking-household purposes -2.17%, fish farming purposes - 0.70% and livestock watering - 0.01% (Figure 2.3).

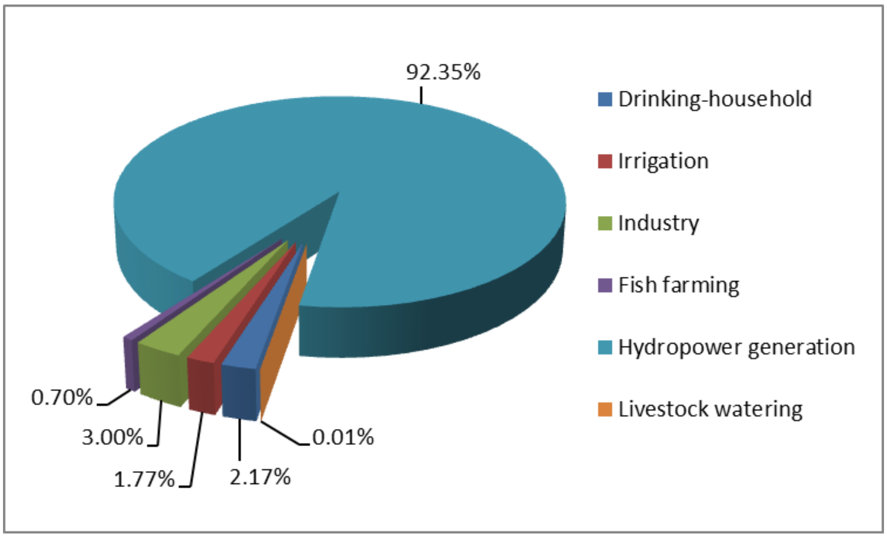


Figure 2.3: Water use by sectors in Southern BMA as of January 2014, % of total water use
Source: State Water Cadastre of WRMA of the RA MNP

Water use by sectors:

Water use for hydropower generation: As of January 2014, water use for hydropower generation in the Southern BMA amounted to 2445 million m^3, 85% of which was mainly used by the Vorotan HPP complex.

There were 3 large HPPs with a cumulative capacity of 405.5 MW, included in the Vorotan HPP complex, and 35 SHPPs with a cumulative capacity of 27.78 MW in the Southern BMA in 2014. Twenty-eight out of the mentioned 35 SHPPs were operated in the Vorotan River Basin.

In the same period about 19 SHPPs with a cumulative capacity of 41.1 MW were under construction in the Southern BMA (Tables 2.6 and 2.7).

Water use for drinking-household purposes: Water supply for drinking-household use in the Southern BMA is mainly provided by the south-eastern branch of the Armenian Water and Sewerage CJSC. The company provides services to 17 settlements in the Vorotan River Basin, 6 settlements in the Voghji River Basin and 5 settlements in the Meghriget River Basin. Water abstraction and supply for drinking-household purposes in the remaining 8 settlements is provided by the villages

According to WUPs, water use for drinking-household purposes in the Southern BMA as of January 2014 amounted to 57.5 million m^3, including 30.3 million m^3 in the Vorotan River Basin and 21.4 and 5.8 million m^3 in the Voghji and Meghriget River Basins, respectively (Table 2.4).

Table 2.4: Settlements of the Southern BMA serviced by the Armenian Water and Sewerage Company

#	Settlement	Water supply, thousand m^3/year	Water sanitation, thousand m^3/year
Vorotan River Basin			
1	t. Sisian	907.92	610.08
2	v. Spandaryan	7.92	0
3	v. Noravan	8.4	0
4	v. Ashotavan	15.96	0
5	v. Hatsavan	3.6	0
6	v. Ishkhanasar	5.88	0
7	v. Uyts	8.4	0
8	t. Goris	774.72	627.84
9	v. Tegh	60.6	0
10	v. Karahunj	38.76	0
11	v. Shinuhayr	37.08	0.84
12	v. Harjis	11.4	0
13	v. Halidzor	29.4	0
14	v. Khot	20.4	0
15	v. Kornidzor	39.24	0
16	v. Hartashen	14.88	0
17	v. Karashen	10.92	0
Voghji River Basin			
18	t. Kapan, including v. Syunik and v. Achanan	4589.2	2198.2
19	t. Kajaran	1210.4	972.0
20	v. Artsvanik	82.17	22.6
21	v. Geghanush	28.12	7.73
Meghriget River Basin			
22	t. Meghri	2601	804.6
23	v. Lehvaz	94.91	43.8
24	v. Gudemnis	21.9	4.01
25	t. Agarak	3970	1151
26	v. Karchevan	94.54	29.2

Source: SCWS of the RA Ministry of Agriculture

According to the Annual Report of the Armenian Water and Sewerage for 2013, actual losses in the water supply system in the Southern BMA make up 73% which is due to extreme wearing-out of the system. The actual water use made up 40% (15 million m^3) of the volume fixed in the WUPs.

Water supply for drinking-household and industrial purposes in the Vorotan River Basin is mainly performed from groundwater springs (with a cumulative discharge of about 1600 l/s), the largest being Mukhuturyan, Akner, Shaqi and Zor-Zor springs.

Water supply for drinking-household purposes in the Voghji and Meghriget River Basins is mainly performed from surface water sources, mainly the Voghji, Geghi, Norashenik, Meghriget and Boghaqar

Rivers. Other sources used for water supply in the above mentioned river basins are Surinkap, Halidzor, Jrakhor, Ayri, Boghakar, Vahravar and Lichk springs.

Water use for irrigation purpose: According to WUPs, water use for irrigation purposes in the Southern BMA as of January 2014 amounted to 46.73 million m^3. Water supply is provided by Sisian, Vorotan, Kapan and Meghri Water use associations (WUAs). Ninety-eight percent of water is abstracted from surface water resources. Water losses in the irrigation network make up 40%. Major part of the arable lands in the Southern BMA is irrigated mechanically.

Main characteristics of HTSs and irrigation systems of the Southern BMA are provided in Tables 2.5 2.8 and 2.9.

Water use for industrial purposes: As of January 2014, according to WUPs, water abstraction for industrial purposes in the Southern BMA amounted to 79.5 million m^3. Ninety nine and six (99.6)% of water abstraction for industrial purposes was performed by Dundee Precious Metals and Zangezur Copper-Molybdenum combines in the Voghji River Basin, as well as Agarak Copper-Molybdenum Combine in the Meghriget River Basin. The rest of water abstraction for industrial purposes, which is 21%, was for food production, processing and other branches of industry.

Water use for fish farming: As of January 2014, according to issued WUPs, water abstraction for fish farming amounted to 18.6 million m^3 in the Southern BMA, including 17.26 million m^3 in the Vorotan River Basin, 1.34 million m^3 in the Voghji River Basin. There were no WUPs issued for water abstraction for fish farming in the Meghriget River Basin. Fish farms in the Southern basin are small-scale, occupying about 1 ha area, and water abstraction is also small.

Water use for livestock watering: of January 2014, according to issued WUPs, water abstraction for livestock watering was carried out only in the Vorotan River Basin and amounted to 0.14 million $m^{3.}$ The Gorhayk, Akner, Tatev and Tsghuk groundwater springs were used for watering.

Water use without permits: Unpermitted water use in the Southern BMA is mostly performed by the population for drinking-household and other purposes. Calculation of volumes of not permitted water use is approximate due to a lack of data, and based on size of villages population and applicable norms.

As of January 2014, the annual water abstraction without permits in the Southern BMA amounted to 6-8 million m^3 in the Vorotan River Basin, 0.3-0.5 million m^3 in the Voghji River Basin and about 1.66 million m^3 in the Meghriget River Basin.

Hydrotechnical structures: capacity, state and water losses

Reservoirs and irrigation systems: According to data provided by the SCWS of the RA Ministry of Agriculture, there are 9 operational reservoirs in the Southern BMA, with largest Spandaryan (the republics second largest reservoir), Tolors, Geghi, Shamb, Angeghakot and Davit-Bek reservoirs.

As of January 2014, the Geghi reservoir was in the stage of rehabilitation, after accident in 2010. Reservoirs are predominantly used for hydropower generation and irrigation (Table 2.5). There are no operational reservoirs in the Meghriget River Basin.

Table 2.5: Technical characteristics of reservoirs in the Southern BMA

Name of the reservoir	*River basin*	*Year of construction*	*Volume, mln^3*	*Dam height, m*	*Mirror surface, ha*	*Area of use*
Spandaryan	Vorotan	1989	257.0	83	1025	En*, Np*, Ir*, In*
Tolors	Sisian	1975	96	69	480	En, Ir
Geghi	Geghi	1990	15	90	35	En, Np, Ir, In
Shamb	Vorotan	1970	13.6	41	112	En

Name of the reservoir	River basin	Year of construction	Volume, mln^3	Dam height, m	Mirror surface, ha	Area of use
Angeghakot	Vorotan	1977	3.4	35	54	En
Davit Bek	Qashun	1990	2.5	40	20	Ir, En
Karahunj	Gorisget	1959	1.27	6	18.3	Ir
Brnakot	Ayriget	-	0.54	7	7.8	Ir, Lw*
Jili	Natural lake near Sev Lich Lake	-	0.14	5.5	28	Ir, Cw

En-energy production, Np-nature protection, Ir-irrigation, In-industry, Lw- livestock watering

Source: SCWS of the RA Ministry of Agriculture

Hydropower facilities: According to the data provided by the Public Services Regulatory Commission (PSRC) of the RA, as of January 2014, the annual cumulative production of the 35 SHPPs with cumulative capacity of 27.87 MW operating in the Southern BMA amounted to 146.8 GWh. Technical characteristics of operational SHPPs are presented in Table 2.6.

Table 2.6: Technical characteristics of operational SHPPs in the Southern BMA

#	Name of the operator	Name of the small HPP	Capacity, kw	Annual output, million kWh	Type of the SHPP	Diversion length, m	Derivation diameter, m	Estimated pressure, m	Estimated discharge, m^3/s	Watercourse
					Vorotan River Basin					
1	“Hakobjanyan and Galstyan HPP” LLC	Shaqi	840	3.4	Natural watercourse	115*2	0.7	54.5	2.1	Shaqi tributary to Vorotan River
2	“Hakobjanyan and Galstyan HPP” LLC	Vorotna HPP	1200	7.08	Natural watercourse	3220	1.4	50.5	3.0	Vorotan
3	"Zangezur-95" CC	Shinuhayr	800	4.31	Natural watercourse	1555	0.8	224.5	0.4	Vorotan
4	"Benzar Energy" LLC	Benzar Energy	279	0.96	Natural watercourse	640	0.8	68.4	0.5	Vaghudi
5	"Lorage t HPP" LLC	Sisakan	514	1.71	Irrigation system	635	0.6	82.8	0.8	Sisian canal
6	"Astghik Hovhannes" LLC	Hoktember	60	0.07	Irrigation systems	520	0.4	38.0	0.2	Loradzor
7	"Single Gor" LLC	Sandaghbyur	621	2.15	Natural watercourse	2450	0.8	100.1	0.8	Sarnagh-byur
8	"Rine" LLC	Rine	90	0.43	Irrigation system	105*2	1.0	4.3	2.8	Spillway dam on the Vorotan River
9	"Pargev and Vardan" LLC	Zor-Zor HPP-1	280	1.11	Natural watercourse	1365	0.6	120.2	3.0	Vaghudi
10	«Engels Tumanyan» LLC "LLC	Gevorgavan	60	0.31	Irrigation system	10	0.5	29.6	0.4	Davit-Bek Reservoir
11	"Smbul" LLC	Smbul	100	0.84	Natural watercourse	351	0.3	85.9	0.2	Smbul
12	"G.A.KH. firm" LLC	Getap	740	1.25	Natural watercourse	4568	0.7	82.0	1.1	Aragli River
13	"Shaghat" LLC	Shaghat	55	0.16	Natural watercourse	1283	0.7	20.2	0.4	Aragli River
14	"Zorakar" CJSC	Ayri	1280	2.29	Natural	4284	1.0	76.0	1.8	Ayriget

#	Name of the operator	Name of the small HPP	Capacity, kw	Annual output, million kWh	Type of the SHPP	Diversion length, m	Derivation diameter, m	Estimated pressure, m	Estimated discharge, m^3/s	Watercourse
					watercourse					
15	"Syunik" LLC	Apres	1500	8.37	Natural watercourse	1700	1.6	53.0	3.3	Vorotan
16	"A.A. Khachatryan" LLC	Shushanik	604	4.06	Natural watercourse	880	0.4	259.5	0.3	Shushanik
17	"Lorаget HPP" LLC	Sisakan-1	853	2.64	Natural watercourse	2196	1.0	75.0	1.5	Dali River
18	"Kh and M Ynkerner" LLC	Vararakn	780	3.6	Natural watercourse	2263	0.7	122.8	0.8	Vararakn
19	"Kanar" CJSC	Sarnakunk	390	2.3	Natural watercourse	920	0.8	104.2	0.5	Sarnakunk tributary
20	"Zh and K HPP"LLC	Angeghakot	150	1.2	Natural watercourse	450	0.3	96.7	0.2	Angeghakot Jaghats spring
21	"Afamia" LLC	Darbas SHPP-2	904	3.6	Natural watercourse	2858	0.8	79.5	1.5	Loradzor tributary to Vorotan River
22	"Khum" LLC	Khum	290	2.0	Irrigation system	136,8	0.5	71.7	0.5	Spandaryan reservoir outlet canal
23	"Smbul" LLC	Manuk	38	0.3	Natural watercourse	630	0.3	67.7	0.1	General Vardan spring
24	"Engels Tumanyan" LLC	Gevorgavan HPP-1	1260	7.6	Irrigation system	20	0.3	280.0	0.5	Karahunj, river, outlet annually regulated reservoirs
25	"Karahunj HPP" LLC	Karahunj 3	1660	11.0	Natural watercourse	1740	1.2	178.2	1.2	Goris River
Voghji River Basin										
26	"Kapan Energy" CJSC	Voghji2,3	1530	34.9	Irrigation system	-	-	-	-	Voghji River
27	"Ler-Ex-Energy" LLC	Ler-Ex HPP-2	224	1.55	Water supply system	-	-	100.2	0.4	Gyard-Ajabaj-Geghi system
28	"Ler-Ex-Energy" LLC	Ler-Ex HPP-4	285	1.77	Water supply system	12.0	0.5	106.3	0.4	Gyard-Ajabaj-Geghi system
29	"Ler-Ex-Energy" LLC	Ler-Ex HPP-6	340	2.32	Water supply system	100.0	0.5	126.8	0.4	Gyard-Ajabaj-Geghi system
30	"Ler-Ex-Energy" LLC	Ler-Ex HPP-3	256	1.95	Water supply system	10.0	0.5	97.6	0.4	Gyard-Ajabaj-Geghi system
31	"Lesma" OJSC	Tsav	2740	6.9	Natural	4765	0.8	286.3	1.2	Tsav River

#	Name of the operator	Name of the small HPP	Capacity, kw	Annual output, million kWh	Type of the SHPP	Diversion length, m	Derivation diameter, m	Estimated pressure, m	Estimated discharge, m^3/s	Watercourse
					watercourse					
32	"Tigran and Ashkhen" OJSC	Tigran and Ashkhen SHPP-1	370	2.0	Irrigation system	24.0	0.5	184.0	0.2	Geghi-Yeghvard irrigation water pipeline
Meghriget River Basin										
33	“Q-H” LLC	Meghri	840	2.1	Water supply system	135*2	0.7	51.0	2.2	Meghriget
34	“Sar-Rub” LLC	Nzhdeh	1732	7.7	Natural watercourse	2020	1.2	65.6	3.4	Meghriget
35	“Gelieguzan” LLC	Kantegh	4200	12.9	Natural watercourse	3280 1090	0.7 1.2	205.8	2.5	Meghriget

Source: RA PSRC

Additional 19 SHPPs with cumulative 41.2 MW annual capacity and 159.1 GWh annual average production are being constructed in the Southern BMA (Table 2.7).

Table 2.7: Technical characteristics of SHPPs being constructed in the Southern BMA

#	Name of the operator	Name of the small HPP	Capacity, kW	Annual output, million kWh	Type of the SHPP	Diversion length, m	Derivation diameter, m	Estimated pressure, m	Estimated discharge, m3/s	Watercourse
Vorotan river basin										
1	"Khachatryan yeghbayrner" LLC	Dali 2	3920	13.5	Natural watercourse	6074	1.0	213.0	2.3	Dali
2	" Veh Loren” LLC	Lor HPP-12	650	2.4	Natural watercourse	2376	0.8	61.3	1.4	Loradzor
3	"HGNK Group" LLC	Vorotan-72	730	3.3	Natural watercourse	932	1.4	18.1	5.0	Vorotan
4	"Kayur HPP"LLC	Mane2	1879	7.1	Natural watercourse	4720	1.4	80.7	3.0	Vorotan
5	"Miezerk" LLC	Ishkhana-sar 2	1702	13.4	Natural watercourse	4356	1.4	74.5	3.0	Vorotan
6	"V.A.L. Energo "LLC	V.A.L 1	200	1.3	Natural watercourse	520	0.8	26.6	1.0	Goris river
7	"Energodzor" LLC	Zor-Zor -21	140	0.9	Natural watercourse	1000	0.5	81.0	0.25	Vaghut tributary of Vorotan river
8	"Aksati" LLC	Arevis-11	620	2.2	Natural watercourse	2225	0.7	117.7	0.7	Gizh tributary of Sisian river
9	"Gurgen -Mher" LLC	Lernashen - 12	719	1.8	Natural watercourse	2083	0.7	128.9	0.7	Lernashen tributary of Vorotan river
10	"Tatev anapat"	Anapat-11	7519.6	25.2	Natural	1072.9	0.7	477.6	2	On

#	Name of the operator	Name of the small HPP	Capacity, kW	Annual output, million kWh	Type of the SHPP	Diversion length, m	Derivation diameter, m	Estimated pressure, m	Estimated discharge, m3/s	Watercourse
	LLC				watercourse	2048 1325	0.8 2*0.6			Aghandzu and Karahunj tributaries of Vorotan river
11	"A G. Hayrapetyans" LLC	Brnakot SHPP-11	635.0	5.3	Irrigation system	0	0	285.4	0.28	Irrigation water pipeline from the Brnakot Reservoir
12	"A G. Hayrapetyans" LLC	Brnakot SHPP-21	378.0	3.1	Irrigation system	0	0	169.9	0.28	
					Voghji river basin					
13	"Tasman" LLC	Geghi-1	4090	15.4	Natural watercourse	6500	1.2	130	3.5	Geghi River
14	"Kapan Energy" CJSC	Voghji-1	4690	15.8	Natural watercourse	600	1.6	97.8	6.0	Voghji River
15	"Ler-Ex-Energy" LLC	Ajabaj-6	1150	3.4	Natural watercourse	1936	0.8	124.7	1.15	Ajabaj tributary to Geghi River
16	"Zangezur Copper-Molybdenum Combine" CJSC	Geghi SHPP-1	2384	8.6	Water supply system	355	1.4	62.5	5.0	Spillway pipeline of Geghi Reservoir
17	"Eremir Energy" LLC	Geghi-2	1780	9.1	Natural watercourse	2640	1.4	49.4	4.5	Geghi tributary to Voghji River
18	"Kajaran Montage" LLC	Dzagedzor SHPP-2	1415	5.2		2650	1.0	126.5	1.40	Baghatsjur tributary to Voghji river
					Meghriget river basin					
19	"Griar" CJSC	Meghri	6520	22.1	Natural watercourse	5145	1.2	245.5	3.3	Meghriget

Source: RA PSRC

Canals and tunnels: According to data provided by the SWCS of the RA Ministry of Agriculture, there are 35 large and small operational canals in the Southern BMA which supply irrigation water to about 10700 ha (Table 2.8). Major part of the canals is in the Vorotan River Basin. Large irrigation canals are the Spandaryan, Vorotan and Angeghakot. Water losses in the canals constitute 25-40%, as a result extreme wearing-out of the systems.

Table 2.8: Technical characteristics of canals in the Southern BMA

Canal name	Length, km	Capacity, l/s	Water abstraction source
Nursery canal	3.6	150	Tolors Reservoir
Bnunis p/s canal	6.8	155	Sisian River
Spandaryan	43.7	2500	Dali River, Mukhuturyan River
Approaching canal to Brnakot Reservoir	4.1	160	Azdak River
Outlet canal form Brnakot Reservoir	45	140	Brnakot Reservoir,

Canal name	Length, km	Capacity, l/s	Water abstraction source
			Angeghakot-Ashotavan tunnel
Brnakot pipeline	25	280	Brnakot Reservoir
Zor-Zor	5	80	Zor-Zor springs
Getatagh	3.9	65	Loraget
Lernashen	3.5	70	Loraget
Darbas	2	60	Loraget
Lori	3.2	41	Loraget
Shebatagh-Lor-Getatagh-Darbas	12	90	Loraget
Dividing canal class II of Tsghuk	4	100	Spandaryan canal
Dividing canal class II of Sarnakunk	6	100	Spandaryan canal
Dividing canal class II of Spandaryan	6	200	Spandaryan canal
Dividing canal class II of Angeghakot	13	700	Spandaryan canal
Dividing canal class II of Shaqi canal	18	200	Spandaryan canal
Dividing canal class II of Ishkhanasar	15	200	Spandaryan canal
Torunik-Akhlatan- Tolors	14	700	Ayri River
Shamb	8	300	Tolors Reservoir
Darbas	6	400	Tolors Reservoir
Getatagh	3	300	Tolors Reservoir
p/s approach canal of Vaghatin	4.8	600	Tolors Reservoir
Vorotan's main canal	27.7	4300	Regulating reservoir of Tatev HPP
Geghi-Eghvard	54	280	Geghi River
Kapan pumping station Canal	0.1	0.4	Geghi River
Tsav-Shikahogh	0.4	0.4	Tsav River
Karchevan	21.2	500	Boghaqar tributary to Meghriget River
Tashtun-Lichk	3.5	400	Tashtun tributary to Meghriget River
Tkhkut	3.4	100	Meghriget River
Shahi / Mayr	6.0	70	Aghbyur River
Vardanidzor	7.5	30	Meghriget River

Source: SCWS of the RA Ministry of Agriculture

The only large underground water pipeline in the Southern BMA is the Vorotan-Arpa tunnel which is designed to transfer 156 million m^3 of water from the Spandaryan Reservoir to Kechut Reservoir annually. Designed length of the tunnel is 21.6 km, and capacity is 15 m^3/s. The Vorotan-Arpa tunnel was not operational in January 2014.

Pumping stations: As of January 2014, there were 50 pumping stations in the Southern BMA. About 30 pumping stations were fully operational, while the remaining were destroyed and in need of rehabilitation (Table 2.9). About 4500-5000 ha arable lands are in the service are of the pumping stations.

Table 2.9: Technical characteristics of operational pumping stations in the Southern BMA

#	*Name of the pumping station*	*Pressure, m*	*Productivity, m^3/hour*	*Installed capacity, kW*	*Water source*
1	Zonal left	300	300	400	Vorotan River
2	Zonal right	240	467	520	Vorotan River
3	Brnakot	310	1900	1680	Angeghakot, Ashotavan tunnel
4	Ashotavan	300	400	320	Sisian River
5	Bnunis	310	1300	1320	Sisian River
6	Tasik	105	180	132	Sisian River
7	Vorotan N1	170	140	1200	Goris main canal
8	Vorotan N2	140	730	2630	Goris main canal
9	Khndzoresk	400	130	960	Khndzoresk River
10	Shinuhayr-Halidzor - Harjis	436	83	1600	Tatev River

#	*Name of the pumping station*	*Pressure, m*	*Productivity, m^3/hour*	*Installed capacity, kW*	*Water source*
11	Kapan 1st degree	300	320	75	Geghi River
12	Kapan 2nd degree	300	320	75	Geghi River
13	Tsav - Shikahogh	420	320	75	Tsav River
14	Karchevan 1	150	400	200	Araks River
15	Arax 1	150	1850	1430	Araks River
16	Araks 2	150	1000	800	Araks River
17	Meghri 1	100	400	200	Araks River
18	Meghri 2	100	195	180	Araks River
19	Meghri 3	50	90	55	Araks River
20	Meghri 4	50	90	55	Araks River
21	Alvank 1st degree	200	870	165	Araks River
22	Alvank 2nd degree	250	1160	950	Araks River
23	Alvank 1-1	200	870	375	Araks River
24	Shvanidzor 1st degree	250	1060	595	Araks River
25	Shvanidzor 2nd degree	150	105	75	Araks River
26	Shahadzor	150	410	130	Araks River
27	Nrnadzor 1st degree	250	1245	1330	Araks River
28	Nrnadzor 2nd degree	200	580	110	Araks River
29	Bughdaduz 1st degree	150	580	103	Araks River
30	Bughdaduz 2nd degree	200	800	320	Araks River
31	Agarak deep well	-	160	45	Groundwater well
32	Alvank deep well	-	25	22	Groundwater well

Source: SCWS of the RA Ministry of Agriculture

Pumping stations of the Southern BMA are serviced by the Sisian, Goris, Kapan and Meghri WUAs. The irrigation of one hectare is quite costly due to high electricity costs of electric pumps. Therefore, WAUs receive financial assistance from the Government of the RA to pay pumping costs. Electric pumps are generally worn out and partially damaged, and as a result, pumping stations operate below their full capacity.

Construction of the Meghri gravity irrigation system by the financial assistance of the World Bank has been commenced since 2014, which will replace the pumping stations and provide irrigation water by gravity to 310 ha of Meghri, Agarak, Shvanidzor, Alvank, Karchevan and Nrnadzor villages.

Volumes of wastewater discharge: Return flows from water use sectors differ by discharge volumes and level of pollution.

About 99.6% of water used for hydropower generation and 98.1% of water used in fish farms are returned to the water resources of the Southern basin without any treatment.

Wastewater discharge is mainly from the industrial sector in the Southern BMA. As of January 2014, it constituted about 80-85% of the total volume of water used. Return flows from other sectors (drinking-household, irrigation) constituted 20-25% of total volume of water abstraction (Table 2.10).

Table 2.10: Volumes of water abstraction and discharge in the Southern BMA, as of January 2014

Water use purpose	Total volume of water abstraction, million m^3/year	Total volume of wastewater discharge, million m^3/year	Wastewater discharge and water abstraction ratio,%
Hydropower generation	2445249.75	2435468.75	99.6
Drinking-household	57502.15	14433.04	25.1

Water use purpose	Total volume of water abstraction, million m^3/year	Total volume of wastewater discharge, million m^3/year	Wastewater discharge and water abstraction ratio,%
Irrigation	46733.31	9346.66	20
Industry	79487.85	70346.75	88.5
Fish farming	18599.34	18245.95	98.1
Livestock watering	140.05	0.00	0
Total	**2647712.45**	**2547841.15**	***96.2***

** after irrigation about 20% of the used water infiltrates back*

Source: State Water Cadastre of the WRMA of the RA MNP

Information on sewage network and wastewater disposal from towns of the Southern BMA is presented in Table 2.11.

Table 2.11: Sewage network and the volume of sewage water in the Southern BMA

Settlement	Length of the main collector, km	Length of the sewer network, km	Including, in need of rehabilitation, km	Discharged untreated wastewater, thousand m^3/year	Receiving Water Resource
t. Goris	6.8	52.1	29.4	2369	Gorisget River
t. Sisian	10.3	58.0	26.0	1264	Vorotan River
t. Kapan	11.0	99.0	26.6	1406.2	Voghji River
t. Kajaran	3.0	9.0	3.5	528.0	Voghji River
t. Meghri	7.0	52.1	29.4	2369	Meghriget River
t. Agarak	8.2	58.0	26.0	1264	Karchevan River
Total	**46.3**	**328.2**	**140.9**	**9200.2**	

Source: SCWS of the RA Ministry of Agriculture

About 46% of the residential sewer network of settlements of the Southern BMA needs to be repaired. Every year, 9.2 million m^3 untreated wastewaters are discharged into rivers. The Gorisget and Meghriget Rivers are receiving more untreated wastewater (Table 2.11).

Drinking water supply systems: In the Southern BMA, centralized drinking water supply system is available in Kapan (with Syunik village), Goris, Kajaran, Meghri and Agarak (with Karchevan village) towns. Technical characteristics of the water supply systems of the specified settlements are provided in Tables 2.12 and 2.13.

Table 2.12: Technical characteristics of internal water supply network and systems in the Southern BMA

Settlement	***Length of the water supply network, km***		
	Total	***Including***	
		External	***Internal (inter-town)***
t. Sisian	69.2	24.6	44.6
t. Goris	137.0	74.0	63.0
t. Kapan	270.0	70.0	200.0
t. Kajaran	31.0	13.0	18.0
t. Meghri	30.0	22.0	8.0
t. Agarak	57.0	42.0	15.0
t. Dastakert	12.0	10.0	2.0

Source: SCWS of the RA Ministry of Agriculture

Table 2.13: Technical characteristics of water supply network and systems in the Southern BMA

Water source	***Location***	***Distance from settlements, km***	***Water spring discharge, l/sec***	***Water pipeline***		***Amount of daily water supply, thousand m^3***	***Daily regulation reservoir, quantity/ volume, m^3***
				Length, km	***Diameter mm***		

Water source	*Location*	*Distance from settlements, km*	*Water spring discharge, l/sec*	*Water pipeline*		*Amount of daily water supply, thousand m^3*	*Daily regulation reservoir, quantity/ volume, m^3*
				Length, km	*Diameter mm*		
t. Sisian							
Shaqi Sevaghbyur Metsaghbyur Blbltan	v. Shaqi t. Sisian t. Sisian t. Sisian	10.0 5.0 6.0 4.0	120 20 22 18	10.0 5.0 6.0 4.0	600 200 200 200	3.76	5/2250 2/1500
t. Goris							
Akner Mukhuturyan	v. Hartashen v. Sarnakunk	13.0 60.0	80 180	13.0 60.0	400 500	5.92	1/1000. 1/500 3/250
t. Kapan							
Geghi, Sevjur	v. Geghi	35.0	90-100	35.0	500	8.1	15/1000 8/500 6/300 4/250 1/100
Surin -Kap	v. David-Bek	12.0	20-25	12.0	200		
Chanakhchi's drinking water treatment plant	v. Okhtar	28.0	40-60	28.0	300		
Geghi's drinking water treatment plant (Ajabaj, Gyard)	v. Tavshut	45.0	200-250	45.0	600		
Jrakhor spring	Jrakhor	8.0	5-7	8.0	150		
Halidzor spring	Halidzor fortress	6.0	7-12	7.0	100		
t. Kajaran							
Yughotdzor	Tributary of Voghji river	7.0	38	7.0	2 X 219	3.886	2/500 2/250
t. Meghri							
Drinking water treatment plant of Meghri	Zvar area	35.0	40	30.0	200	0.99	2/1000 2/500
Setanc spring	t. Meghri	8.0	17	8.0	150		
t. Agarak							
Drinking water treatment plant of Ayri river	Tributary of Meghriget river	23.0	50	23.0	400	1.16	1/500 1/300 1/200

Source: SCWS of the RA Ministry of Agriculture

Wastewater treatment systems: Previously, Kapan, Sisian and Kajaran wastewater treatment plants (WWTPs) were operating in Southern BMA. These are currently ruined and in a dilapidated condition. Currently, communal wastewater of the mentioned towns, as well as wastewaters from manufacturing facilities is discharged into the Voghji, Vorotan, Gorisget Rivers through gravity sewerage without treatment and disinfection.

The WWTP of Kapan town with 25000 m^3/day capacity was constructed in 1975 and was designed to treat wastewaters of Kapan and Syunik villages. There is a half-constructed (1990) WWTP at Sisian town with 7000m^3/day designed capacity. The WWTP of Kajaran town with 4000 m^3/day capacity was built in 1959 by the Zangezur Copper-Molybdenum Combine and designed to treat town wastewaters only. There are no WWTPs in towns of the Meghriget River Basin.

2.2.2. Natural Flow, Water Demand and Supply Balance

Multiyear average natural flow for the rivers of the Southern BMA at the hydrological monitoring points was calculated by riverbed and water balance elements, using data for the period of 1961-2012 (Table 2.14).

Table 2.14: Calculated multiyear average natural flow of the rivers of the Southern BMA

#	River-observation point	Actual flow, m^3/s	Natural flow, m^3/s
Vorotan River Basin			
1	Vorotan- Koshabulagh *	2.99	3.08
2	Vorotan- Gorhayk	3.51	3.77
3	Vorotan- Borisovka *	6.99	7.62
4	Vorotan-Angeghakot *	10.1	10.8
5	Vorotan-Vorotan	10.06	18.3
6	Vorotan- Tatev HPPs	20.6	21.4
7	Daliget-Borisovka *	1.26	1.47
8	Tsghuk-Tsghuk	1.44	1.62
9	Sisian- Arevis *	1.79	1.88
10	Sisian- Ashotavan *	3.03	3.80
11	Loradzor-Ltsen *	0.96	1.01
12	Tate- Tatev *	1.34	2.02
13	Goris-Goris	0.54	0.71
Voghji River Basin			
14	Voghji - Kapan	10.6	10.7
15	Geghi - Kavchut	4.12	5.41
16	Vachagan –Kapan	0.40	0.41
Meghriget River Basin			
17	Meghriget- Lichk *	0.59	0.63
18	Meghriget- Meghri	2.87	3.17
19	Karchevan-Agarak *	0.043	0.05
20	Astazurget-Shvanidzor *	0.049	0.05

* closed observation point

Source: Armstathydromet service of the RA Ministry of Territorial Administration and Emergency Situations

Water demand and supply balance: Water demand and supply balance of the rivers of the Southern BMA was prepared with consideration of catchments of the Vorotan-Tatev HPP (up to the border of the Republic of Armenia), Gorisget-Goris, Voghji-Kapan (up to the border of the Republic of Armenia), Tsav-Nerkin Hand (up to the state border) and Meghriget-Meghri hydrological monitoring points. Calculation results show that as of January 2014 demand and supply balance of the river basins of the Southern BMA had positive indicators (Table 2.15).

Table 2.15: Water demand and supply balance of the rivers of the Southern BMA, as of January 2014

River-observation point	Balance, million m^3	River flow, million m^3	Cumulative water abstraction, million m^3	Return waters, million m^3	Ecological flow, million m^3	Actual flow, million m^3
Vorotan-Tatev HPP	+517.34	674.96	63.11	25.34	119.85	649.73
Gorisget-Goris	+15.12	22.39	1.82	0.86	6.31	17.03
Voghji-Kapan	+289.2	337.2	327.51	309.46	29.96	332.7
Tsav-Nerkin Hand	+86.6	91.47	24.44	24.34	4.73	91.5
Meghriget-Meghri	+76.92	99.98	84.4	66.7	5.36	90.52

2.3. Water Quality

Analyzes provided in this section are based on data provided by the Environmental Impact Monitoring Center (EIMC) and Hydrogeological Monitoring Center (HMC) SNCOs of the RA MNP.

Assessment of water quality of the rivers in the Southern BMA: Water quality in the rivers of the Southern BMA was assessed based on hydrochemical parameters only, due to a lack of biological monitoring in the rivers of the Republic of Armenia. Assessment of quality of surface waters of the Southern BMA is based on monthly and average annual water quality monitoring data for the period of 2007-2013 provided by the EIMC, as well as data contained in the Environmental Impact Assessment (EIA) reports provided by some mining companies. An expert assessment was provided in cases of absence of hydrochemical data for the rivers. Water quality of the Vorotan, Gorisget, Sisian, Ayriget and Kishkosht rivers of the Vorotan River Basin, the Voghji, Geghi, Artsvanik, Vachagan, Norashenik, Tsav rivers of the Voghji River Basin and the Meghriget, Boghaqar, Karchevan rivers of the Meghriget River Basin, as well as of other small tributaries of the mentioned river basins was assessed (Figure 2.4, Annex B1).

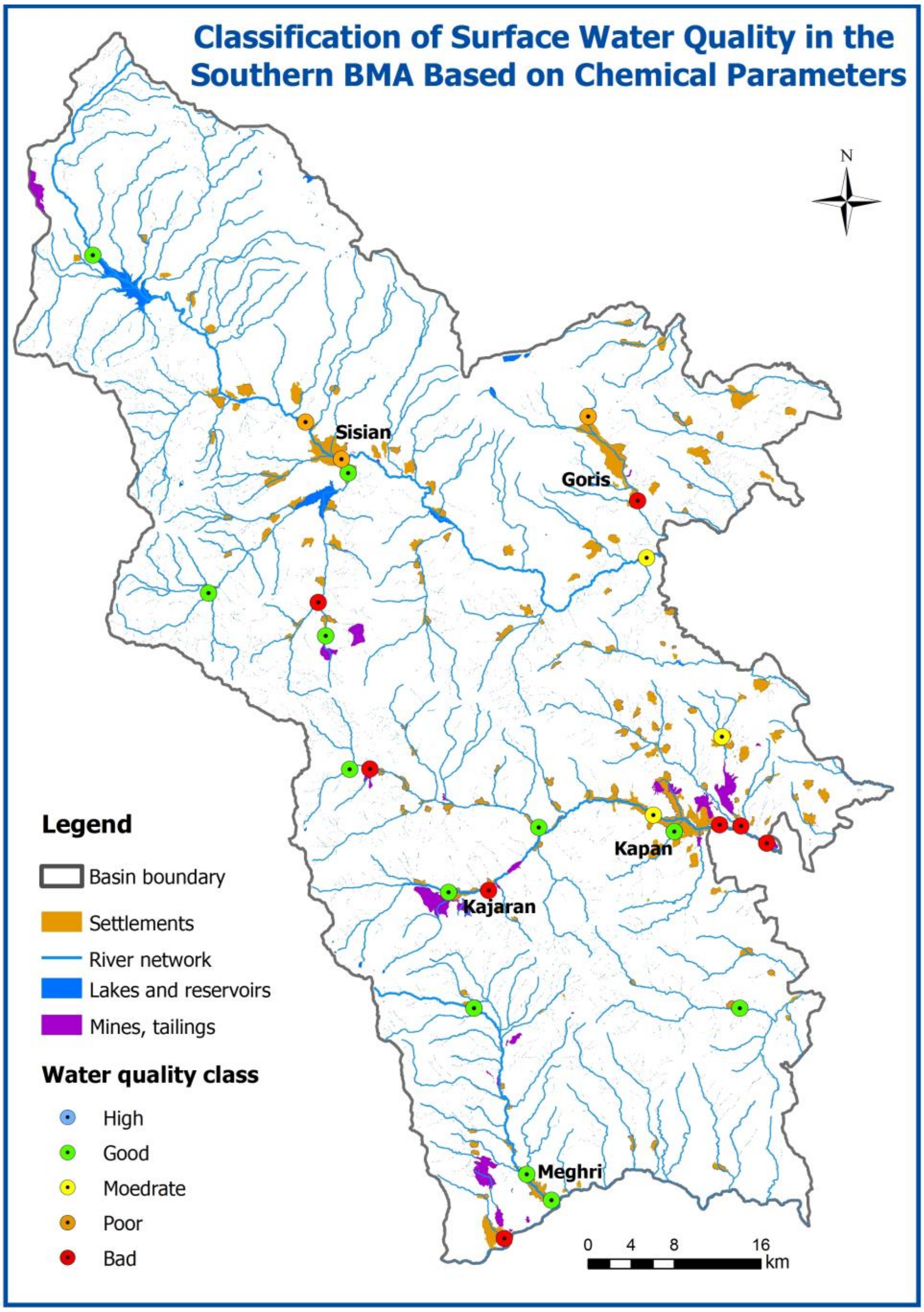


Figure 2.4: Classification of water quality in the rivers of the Southern BMA by chemical elements

Source: USAID Clean Energy and Water Program, 2014 (Coordinate System WGS, UTM Zone 38N)

Classification of river water quality is based on surface water quality norms/standards set by RA Government Decision No 75-N and requirements of the European Union's Water Framework Directive (EU WFD).

According to results of the water quality assessment of the rivers of the Southern BMA, rivers are mainly polluted by communal wastewater, solid wastes, agricultural return flows, mining wastewater, as well as runoff and surface flows formed in the open pits and tailing areas.

Pollution of rivers with communal wastewater: Concentration of nutrients sharply increases in the middle and lower reaches of the rivers of the Southern BMA due to communal wastewater discharge downstream the settlements (the Vorotan River near the Sisian town, the Gorisget River near the Goris town, the Voghji river downstream the Kajaran and Kapan towns). Water quality at the mentioned river sections downstream the towns decreases from good (II) to poor (IV) (in the case of Sisian and Goris towns), from moderate (III) (in case of Kapan) and Bad (V) (in case of Kajaran) water quality classes by concentrations of ammonium and phosphate ions (Figure 2.4, Annex B1). In addition to pollution with wastewaters, the rivers of the Southern BMA are also polluted with solid waste while passing the urban settlements. Particularly, the Vorotan River is polluted with solid wastes in the Sisian town, the Gorisget River - in Goris, the Voghji River - in Kajaran and Kapan towns, the Vachagan River in Kapan, the Meghriget River in Meghri, and the Karchevan - in Agarak town.

Pollution of rivers with agricultural return flows: Agriculture has significant pressure on the river water quality. The Vorotan and Gorisget Rivers in the Vorotan River Basin and the Artsvanik River in the Voghji River Basin are polluted in the result of wrong agricultural practices (use of fertilizers and pesticides). In a result of incorrect doses and practices of applying fertilizers and pesticides for the fields' treatment, surface runoff from the irrigated lands discharges into the rivers and pollutes waters with chemical compounds. Water quality in the middle and lower reaches of the Vorotan and Gorisget Rivers decreases from good (II) to moderate (III) and poor (IV) classes of water quality, in case of the Artsvanik River – from moderate (III) to poor (IV) and bad (V) quality classes. In both cases it is due to increased concentrations of nitrite and phosphorus ions, as a result of return flows from irrigation of arable lands (Figure 2.4, Annex B1).

Pollution of rivers from mining operations: Rivers of the Southern BMA are continuously polluted with large amounts of heavy metals as a result of rapid development of the mining industry. The Kishkosht and Ayriget tributaries of the Sisian River in the Vorotan River Basin, the Voghji River and its Geghi, Artsvanik, Norashenik, Kavart and Geghanush tributaries in the Voghji River Basin, as well as the Meghriget and Karchevan Rivers with their Khachidzor and Agarak tributaries in the Meghriget River Basin are polluted in the result of exploitation of metal mines, as well as with runoff from operational and already reclaimed tailings.

According to hydrochemical monitoring data provided in the EIA report prepared by the World of Molybdenum company for the Dastakert Copper-Molybdenum Mine for the period of 2011-2012, water quality of the Kishkosht and Ayriget tributaries to the Sisian River in the Vorotan River Basin decreases downstream from good (II) to bad (V) water quality class (Annex B1). Surface runoff formed by precipitation in the area of non-operational Dastakert open mine, as well as eroded areas of reclaimed tailing dam pollutes the Kishkosht River with heavy metals, which transports the pollution into the Ayriget River. Settling of metals takes place in waters of Kishkosht and Ayriget Rivers. Dissolved metals settle in the sludge, thus accumulating in the riverbeds. In the result, high metal concentrations at the mouth of the Ayriget River decrease and do not pollute the Sisian River. However, the continuous pollution of the Kishkosht and Ayriget riverbeds will eventually seriously damage the aquatic ecosystems, and the rivers will completely lose self-purification capacity. This will lead to pollution of the - Sisian and Vorotan main rivers.

Water quality of the Voghji River downstream the Kajaran town decreases from good (II) to moderate (III) and poor (IV) quality classes as a result of discharge of the Kajaran Copper-Molybdenum Combine wastewater and surface runoff from the open mine into the river. Due to continuous pollution of the river with heavy metals, the section of the Voghji River downstream the mine, has no self-purification capacity, and downstream the Kapan town airport, after receiving waters of the Artsvanik, Norashenik and Kavart tributaries, quality of the river deteriorates more and corresponds to bad (V) quality class (Figure 2.4, Annex B1).

According to hydrochemical monitoring data, the Artsvanik tributary to the Voghji River is intensively polluted by surface runoff from the eroded sections of the Artsvanik tailing dam, as well as infiltration of polluted water of the tailing dam. These results in the decrease of the water quality class from moderate (III) to poor (IV) due to presence of toxic heavy metals (cobalt, cadmium, manganese, molybdenum and arsenic) and elements of mineralization regime. Aquatic ecosystem in the middle and lower reaches of the Artsvanik River has been entirely damaged due to anthropogenic pressure. No aquatic species (phytoplankton, zooplankton, zoobenthos and fish) is found at Artsvanik River.

According to hydrochemical monitoring data for 2007-2013, water quality of the Geghi tributary to Voghji River near Ajabaj village has decreased from good (II) to bad (V) class since 2013. This is a result of activities of the Ler-Ex company. Despite activities of the Ler-Ex company has been ceased, still wastewater flows from the abandoned Geghi settling ponds pollute the Geghi River with manganese, molybdenum and other elements of mineralization regime Settling of heavy metals downstream the discharge point (self-purification capacity of the river) reduces anthropogenic pressure, and quality of water in the Geghi River downstream the Now Astghaberd village improves and corresponds to good (II) water quality class (Annex B1).

According to expert assessment, anthropogenic pressure extends to the Tsakkar and Kavart tributaries to the Voghji River and right tributaries to the Geghi River, as well as the Darapi right-side tributary to the Voghji River. The Darapi tributary is between the Kajaran and Pkhrut Rivers that flowing through the waste dump area of the Zangezur Copper-Molybdenum Mine. Waters of these rivers are polluted with heavy metals that are washed out from the mine dumps and settling ponds. The Norashenik tributary to the Voghji River is also polluted with heavy metals and other resides from the mines.

According to expert observations, a part of technical wash-waters of the mine operated by Dundee Precious Metals and production waters of the Zangezur Copper-Molybdenum Combine CJSCs, as well as leaks from the pipeline diverting wastewater to the Artsvanik tailing dam are discharged into the Norashenik River.

Mining operations in the Meghriget River Basin of the Southern BMA cause pollution of the Meghriget and Karchevan Rivers and their tributaries. According to hydrochemical monitoring data provided in the EIA report of the Sagamar CJSC for the Lichkvaz-Tey Gold and Copper Mine for the period of 2011-2012, water quality of the Meghriget River downstream the Tkhkut village during summer months decreases from good (II) to bad (V) class (Figure 2.4). During snow melt and heavy rains, surface runoff formed in the result of washing out the mine dumps and settling ponds located at the river's right bank, discharge into the Meghriget River and pollute it with heavy metals. Due to rapid settling of the heavy metals and self-purification capacity of the river, water quality improves 2-3 km downstream the pollution sources and corresponds to good (II) quality class. However, heavy metals do not leave the aquatic ecosystem during water quality improvement, but accumulate in the bottom sediment thus contaminating the riverbed and damaging benthic species.

Water quality of the Meghriget River, downstream the confluence of the Karchevan River, corresponds to bad (V) class. It is a result of untreated wastewater discharge in to the Karchevan River by the Agarak Copper-Molybdenum Combine. (Annex B1). Due to a high level of anthropogenic pressure, the natural ecological state of the river is completely disrupted. No aquatic diversity (phytoplankton, zooplankton, zoobenthos and fish) is found in the river. The Karchevan River has a metallic shade, odor and taste due to high level of mineralization and the concentration of heavy metals (manganese, copper, molybdenum, zinc, iron, lead, arsenic, etc.). River water is characterized with alkaline environment and has sodium-sulphate nature, which is conditioned by extremely high concentration of suspended particles (reaching up to 16000 mg/l). The river water is polluted with large amounts of hardly degradable, long-chain organic substances, which are staying long in the aquatic ecosystems (Annex B1). Bad quality of the Karchevan River is a result of the pressure posed by the effluents of the Agarak Combine.

According to expert assessment, anthropogenic pressure from the Agarak Mine extends on the Khachidzor tributary to the Meghriget River and Agarak tributary to the Karchevan River. These rivers of the Meghriget River Basin passing through the mine dumps and settling ponds, and get polluted by heavy metals and other substances.

Assessment of groundwater quality in the Southern BMA: Quality of groundwater resources in the Southern BMA was assessed based on data for the period of 2009-2013 provided by the Hydrogeological Monitoring Center of the RA MNP. The assessment covers groundwater sources in Sisian and Goris regions of the Vorotan River Basin. Expert assessment was provided for quality of groundwater resources in the Voghji and Meghriget River Basins due to a lack of relevant data.

According to the data of the Hydrogeological Monitoring Center, quality of groundwater resources in the Sisian and Goris regions of the Southern BMA corresponds to excellent and good classes. No harmful chemicals were detected in the water samples and the generalized chemical indicators were in compliance with drinking water standards defined by the order # 876-P of the Minister of Healthcare of RA, adopted in 2002.

Groundwater quality in the Voghji and Meghriget River Basins was assessed based on expert judgment and data available for the period before 1990s. The chemical status of groundwater resources at high hypsometric marks (1500 m and higher) of the mentioned river basins corresponds to good quality class. Quality of groundwater resources in the lower hypsometric marks correspond to bad quality class, as a result of tailing dumps, open mines, and diffuse pollution for agriculture, household wastewaters of settlements, etc. Nevertheless, the expert assessment is not sufficient for accurate assessment of groundwater quality in these river basins. It is necessary to develop and implement a new program for groundwater quantity and quality monitoring.

Assessment of suitability of water resources in the Southern BMA for use for irrigation, fish farming and drinking: assessment of suitability of waters in the rivers of the Southern BAM in terms of their suitability for using for irrigation and fish farming purposes based on the quality is provided in Annex B2.

Assessment of surface waters suitability for irrigation purposes: Suitability of waters for irrigation purposes is assessed and limitations of water use for irrigation is given based on international standards on suitability of water for irrigation purposes (set by UN FAO in 1994 and the US Institute of Soil Science (Ayers, 1977)), as well as standards set by Annex 1 of the RA Government Decisions No 75-N. Surface water quality data of the EIMC of the RA MNP for the period of 2007-2013 data is used.

According to the assessment results, water quality of the Vorotan, Sisian, Gorisget, Voghji, Geghi, Vachagan, Tsav and Meghriget rivers, as well as upper reaches of the Artsvanik River, in terms of suitability for irrigation, correspond to excellent and good classes. These can be used for irrigation of frequently irrigated soils with good drainage capacity. Waters of the middle reaches of the Artsvanik River correspond to moderate quality class, and can be used for irrigation in case of minimization of contact with crop leaves (Annex B2).

In terms of limitations for using waters for irrigation purposes in the Southern BMA, the waters of upper reaches of the Vorotan and Gorisget Rivers can be used without any limitation. Whereas, waters of lower reaches of the mentioned, as well as the Sisian, Geghi, Vachagan, Tsav, Meghriget rivers, upstream waters of the Voghji River (from headwaters to downstream the Kapan town) can be used for irrigation with moderate limitations. Moderate limitation excludes irrigation of sensitive crops.

Waters of the Artsvanik and Karchevan Rivers, as well middle and lower reaches of the Voghji River are restricted for use for irrigation purposes due to a high level of mineralization and concentration of heavy metals (Annex B2).

Assessment of surface waters suitability for fish farming purposes: Suitability of waters in the rivers of the Southern BMA for fish farming purposes is assessed based on Annex 1 of the RA Government Decision No. 75-N. Based on the quality class, water's suitability for salmon and carp fish species breeding was determined (Annex B2).

According to the assessment, fish breeding in the Southern BMA can be further developed primarily in the upstream sections of the Vorotan (before the town of Sisian) and Sisian Rivers, since qualitative features of these waters are suitable for salmon and carp fish species breeding. Middle and lower reaches of the Vorotan (up to the point downstream the Tatev HPP), as well as the Gorisget River entirely are unsuitable for fish farming purposes, due to contamination with communal wastewater.

Waters of the Kishkosht and Ayriget Rivers are also unsuitable for fish farming, due to their pollution with surface runoff from the non-operation Dastakert open mine and tailing areas.

The Voghji and Meghriget River Basins are intensively polluted with large amounts of heavy metals due to rapid development of the mining industry. Thus, waters of the middle and lower reaches of the Voghji River, Vachagan, Kavart, Artsvanik Rivers, a section of the Geghi River between the Ajabaj and Nor Astghaberd villages, as well as middle stream of the Meghriget and Karchevan rivers are not suitable and not allowed to be used for fish farming purposes. Fish farming development is possible only in the Geghi and Tsav Rivers of the Voghji River Basin, as well as in the Meghriget River Basin, particularly in the upstream reaches of the Meghriget River and its Boghakar tributary, where quality of water corresponds to good (II) class.

Assessment of waters suitability for drinking purposes: Drinking water in the Southern BMA is supplied from both groundwater and surface waters (mainly in the Voghji and Meghriget River Basins).

Chemical parameters of groundwater resources in the Vorotan River Basin of the Southern BMA comply with standards and rules approved by Order No. 876-N of the RA Minister of Healthcare adopted in 2002 and after pre-treatment (disinfection) can be used for drinking purposes without limitations.

In the Voghji and Meghriget River Basins, considering geochemical characteristics of groundwater sources at the high hypsometric marks where there is no anthropogenic pressures, groundwater resources, based on the expert judgment, can be used for drinking purposes without any limitations after pre-treatment (disinfection). Groundwater resources at lower hypsometric marks are vulnerable to anthropogenic impact - mining and agricultural activities. According to expert judgment, these waters could be polluted with heavy metals, pesticides and nitrogen compounds. Therefore, these water sources are assessed as being risky for using for drinking purposes.

Only headwaters of the following rivers in the Southern BAM are allowed to be used for drinking purposes: the Vorotan and Sisian Rivers in the Vorotan River Basin, the Geghi and Tsav Rivers in the Voghji River Basin and the Meghriget River in the Meghriget River Basin. Chemical parameters of headwaters of these rivers are free of anthropogenic impacts and comply with drinking water standards and rules approved by the Order No. 876-N of the RA Minister of Healthcare, adopted in 2002, and after pre-treatment (disinfection) can be used for drinking purposes without limitations (Annex B2).

Chemical parameters of headwaters of other rivers in the Southern BMA (Gorisget, Voghji, Vachagan, Artsvanik, Boghakar and Karchevan) do not meet the drinking water requirements.

2.4. General Overview of Current Issues

Main issues identified in the result of analyses of quality and quantity of the rivers in the Southern BMA as of January 2014, are presented in Table 2.18.

Table 2.18: Summary of key issues revealed in the Southern BMA and their causes

Issue	Cause
Water deficit during irrigation season	Worn out and degraded irrigation systems, Slow-paced development of irrigation infrastructure, Insufficient water volume due to its use by other sectors, particularly, hydropower generation by the Vorotan HPP complex and SHPPs
Occurrence of mudflows in the BMA	Insufficient level of measures to prevent mudflows
Occurrence of landslides in the BMA	Insufficient level of measures to prevent landslides
Growth of concentrations of substances of nutritional regime in the river waters downstream the settlements	Absence of sewerage collector networks in the rural communities, Pollution with communal wastewater and return flows from livestock breeding, Absence of communal wastewater treatment plants in rural and urban communities
Potential growth of nitrogen concentrations in the rivers	Diffuse/non-point source pollution from agriculture
Potential growth of calcium concentrations in the rivers and increasing hardness of water	Growth of erosion processes and reduction of forest-covered areas in the BMA
Changes in thermal regime in the middle and lower reaches of the rivers	Presence of HPPs and reservoirs in the BMA
Growth trend of heavy metal concentrations in the rivers in the mining areas	Pollution with mining waste and dumps
Potential growth heavy metals concentrations in the middle and lower reaches of the rivers	Pollution with mine tailings and filtered waters of tailings
Significant changes of hydromorphological conditions in the rivers, which have resulted in non-maintenance of the ecological flow requirements	Presence of HPPs and reservoirs, industrial water use in the BMA

2.5. Water Supply Formation Strategy in the Southern BMA

Water supply formation/availability strategy in the Southern BMA is provided in section 1.3. Implementation of the concept of the perspective program for reservoir construction will create about 219.4 million m^3 of additional water storage capacity. It will increase the water flow regulation capabilities and solve strategic issues, such as:

- Expansion of irrigated lands,
- Transformation of the majority of mechanical irrigation systems into gravity systems,
- Creation of a new potential for increasing hydropower generation in the rivers of the basin,
- Protection of settlements, agricultural lands and communications of riparian areas from mudflows and flooding,
- Ensuring water supply during the low-flow periods,
- Establishing water protection and recreational zones.

2.6. Identification of Likely Emergency Situations and Other Hazards related to Water Use in Basin Management Area

Water resources in Armenia are used by means of water use systems, which, according to RA Law on National Water Program are classified according to strategic and social-economic importance, environmental significance and degree of potential disruption risk and impacts of a likely accident.
Possible emergency situations and other dangerous phenomena may occur in the Southern BMA in the result of failure of the following:

- Reservoirs, canals, pumping stations and other HTSs used for irrigation,
- Water supply and sanitation systems, daily regulation reservoirs used for municipal-drinking water supply and wastewater disposal,
- Industrial pipelines and tailing dams,
- HPPs and their infrastructure.

According to the RA Law on National Water Program, the following HTS in the Southern BMA are of high risk in terms of creating possible emergency situations:

- The Vorotan-Arpa-Sevan tunnel, Spandaryan, Tolors, Davit Bek and Geghi Reservoirs,
- Daily regulation reservoirs of the Kapan, Sisian, Goris, Kajaran and Agarak towns,
- Catchment structures of the Geghi, Norashenik, Ayriget and Lichk Rivers and Mukhuturyan, Akner, Zor-Zor, Shaqi, Zuygaghbyur, Geghi, Surinkap, Vahravar, Ayri and Lichk groundwater springs,
- Canals and pipelines of the Spandaryan, Shamb and Tatev HPPs.

Disastrous water flows will form in the result of complete or partial collapse of the dams, which will cause significant damage in the river floodplains, surrounding areas resulting in casualties and economic damages. Partial or complete collapse of the Spandaryan reservoir dam will lead to collapse of the Angeghakot and Shamb reservoirs, and the damage caused by the Vorotan River will extend from the Spandaryan reservoir to the Araks River.

The building of Spandaryan HPP will be partially or completely damaged, about 200 ha near the Shaghat, Balak and Angeghakot villages and houses adjacent to the Vorotan riverbed will be flooded, disastrous flows formed will discharge into the Angeghakot reservoir in case of collapse of the Spandaryan reservoir dam. About 900-950 ha areas under houses, residential buildings and structures, cultivated lands and other economic infrastructure of the Sisian town and Uyts settlement will be flooded in the result of the collapse of Angeghakot reservoir dam. Houses, residential buildings and land of the Vaghatin and Vorotan villages will also be partially flooded and destroyed. Damage will be caused to the buildings of the Shamb HPP. Formed disastrous flows will discharge into the Shamb reservoir causing the collapse of the reservoir dam. Reservoir waters will reach up to the Araks River and damage the Tatev HPP building, structures and surrounding areas of the riverbed. Extensive damages will occur at the area between Sisian town and Araks river complete or partial collapse of Tolors reservoir. Complete or partial collapse of the Geghi reservoir dam will result in a damage of a few houses of the Kavchut settlement downstream the Geghi River, engineering structures, the bridge connecting Kajaran-Kapan highway, as well as lands and structures stretching from the Kapan town to the border of the Republic of Armenia. There are HTS with high risk in terms of creating emergency situations in the Meghriget River Basin.

2.7. Conclusions and Recommendations

Desired conditions and main water use function directions are defined by the RA Laws on Fundamental Provisions of the National Water Policy and National Water Program, as well as a number of government decrees and regulations.

Development priorities at national and basin, as well as river basin scales were taken into consideration while determining the water use priority functions in the Southern BMA. Desired water use conditions were determined by consideration of quality and quantity of available water resources, excluding the possibility of anthropogenic impact on ecosystems.

Water use in the rivers basins of the Southern BMA and results of the water quality assessment as of January 2014, expected changes in quantity and quality of water resources were taken into consideration while defining water use priorities in the Southern BMA.

Water use priorities suggested for the Southern BMA coincide with priorities set out by the RA legislation. These are maintenance of the ecological flow requirements, water use for drinking-household, irrigation, hydropower generation, industrial and recreation purposes.

Target directions proposed for achieving desired water use conditions in the Southern BMA are provided in Table 2.20, while target directions for water quality protection are provided in Table 2.21.

Table 2.20: Water use priorities and target directions in the Southern BMA

Water use priority	Target direction
Ecological flow	Calculation of values of ecological flow using integrated approach and strict maintenance of this requirement
Drinking-household	Strict protection of drinking and mineral water resources, as well as elaboration of a system of efficient use of these resources
Irrigation	River flow management and regulation, including development of gravity irrigation systems
Hydropower production	Development of hydropower generation sector through construction of SHPPs with strict maintenance of the ecological flow
Industry	Specification of water use conditions and development of enforcement mechanism for industry, including food production and mining sectors, introduction and use of best available technologies
Recreation	Protection and development of water resources for recreational purposes

Table 2.21: Target water quality directions in the Southern BMA

Priority	Target direction
Water Quality Protection	Development and of centralized wastewater collection and treatment system
	Development of a system aimed at prevention of non-point source pollution of water resources
	Development of a special system aimed at prevention of pollution of waters with mining wastewaters

It is proposed to establish hydrological reserves at the upper reaches of the Vorotan, Meghriget, Voghji and Geghi Rivers in the Southern BMA, as well as to ensure the protection regime of the Sev Lich State Sanctuary according to the requirements of the RA Law Specially Protected Nature areas.

A Program of Measures designed for achieving desired conditions in the Southern BMA is presented in Chapter 6.

CHAPTER 3: ASSESSMENT OF NATURAL AND ANTHROPOGENIC IMPACTS ON WATER RESOURCES

3.1. Summary

Natural climatic changes and economic activities are having impact on water resources. Impact of climate change on water resources of the Southern BMA is already noticeable.

Both anthropogenic and natural pressures and impacts are analyzed, including climate change, hazardous process that may lead to emergencies, such as impact of low-flow and high-flow water years, floods and mudflows.

3.2. Climate Change Impact Assessment in the Southern BMA

According to the assessment reports of the Intergovernmental Panel on Climate Change (IPCC), the increase in GHG emissions in the atmosphere may lead to drastic changes in the global climate during the 21st century. These changes are expected to disrupt the natural hydrological cycle, increasing evaporation rates and accumulation of large amounts of water vapor in the atmosphere. As a result, changes in long-term precipitation patterns, climatic extremes, soil humidity levels and flow dynamics are expected to be observed.

This section provides the analysis of changing trends in climatic elements and the river flow observed in the period of 1961-2011, as well as projected scenarios of climate change and the potential impacts on the river flow of the Southern Basin in short-, medium- and long-term horizons. The analyses are based on the data provided by the ArmstateHydromet Service of the Ministry of Territorial Administration and Emergency Situations (MTAES), the WRMA and EIMC of the RA MNP.

3.2.1. Observed Trends in Climatic Parameters

Systematic observation data time-series obtained from 6 operational meteorological stations in the Southern BMA have been used for analyzing the observed trends in climatic elements in the basin.

Annual and seasonal deviations of observed climatic elements have been assessed for the period of 1991-2011 against the baseline average values for 1961-1990, established by the World Meteorological Organization (WMO). The assessment results are summarized below.

Changes in air temperature: Analysis of systematic observation data indicates that the annual air temperature has increased in the Southern BMA by 0.02-0.9°C against the average values for 1961-1990. The highest deviations from the norm are observed during the last 10-15 years (Figure 3.1, Table 3.1)

Table 3.1: Deviations of annual average air temperature values in the period of 1991-2011 against the baseline average for 1961-1990 in the Southern BMA, °C

Meteorological station	*1961-1990*	*1991-2011*	*Deviation*
	Vorotan River Basin		
Goris	8.81	9.70	0.89
Sisian	7.04	7.61	0.57
Vorotan Pass	2.61	3.16	0.55
	Voghji River Basin		
Kajaran	6.79	6,81	0.02
Kapan	12.07	12.61	0,54
	Meghriget River Basin		
Meghri	14.22	15.01	0.79

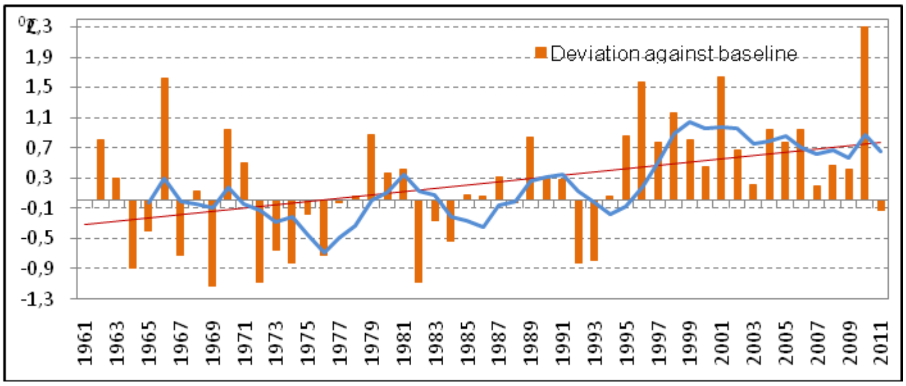


Figure 3.1: Deviations of annual average air temperature values against the baseline average for 1961-1990 in the Southern BMA, $^{\circ}$C

According to analysis results, intra-annual average temperature has increased within the range of 0.1 and 1.1^{0}C degrees during all seasons in the period of 1991-2011 in the Southern BMA (Figure 3.2). Maximum deviations of seasonal average values of air temperature from the norm were observed during summer months by 0.4-1.1^{0}C, the air temperature increased by an average of 0.5^{0}C during the months of spring and fall, and by 0.3^{0}C during winter (Figure 3.2).

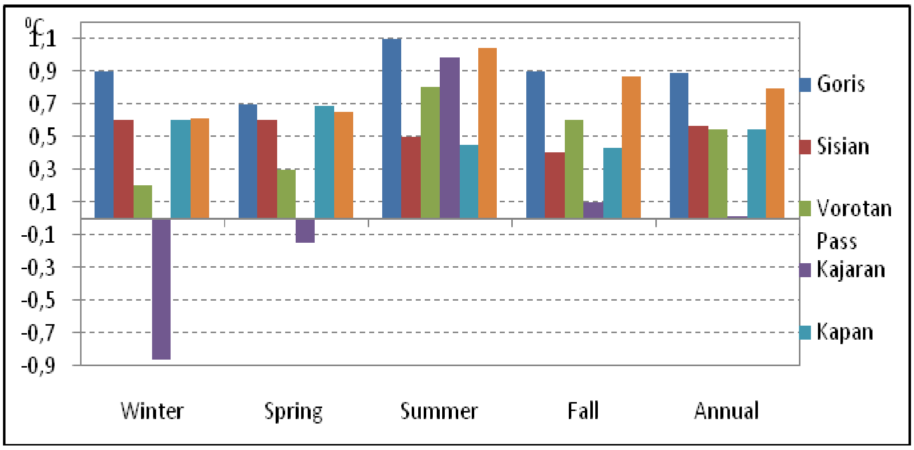


Figure 3.2: Deviations of annual and seasonal average air temperature values for 1991-2011 against the baseline average for 1961-1990 in the Southern BMA, $^{\circ}$C

The analysis of annual average maximum air temperature in the Southern BMA shows an increase by 0.4^{0}C-1.6^{0}C. The annual average minimum temperature at Voghji and Meghriget River Basins has increased by 0.4^{0}C-0.8^{0}C, while in the Vorotan River Basin the change in values has not been of a regular pattern(Tables 3.2 and 3.3).

Table 3.2: Deviations of annual average maximum air temperature during 1991-2011 against the baseline average for 1961-1990 in the Southern BMA, $^{\circ}$C

Meteorological station	*1961-1990*	*1991-2011*	*Deviation*
	Vorotan River Basin		
Goris	20.9	22.5	1.6
Sisian	8.8	9.2	0.4
Vorotan Pass	4.3	5.0	0.7
	Voghji River Basin		
Kajaran	12.8	13.5	0.7
Kapan	18.9	19.5	0.6
	Meghriget River Basin		
Meghri	19.9	20.5	0.6

Table 3.3: Deviations of annual average minimum air temperature during 1991-2011 against the baseline average values for 1961-1990 in the Southern BMA, °C

Meteorological station	*1961-1990*	*1991-2011*	*Deviation*
	Vorotan River Basin		
Goris	7.6	7.9	0.3
Sisian	-2.8	-2.4	0.4
Vorotan Pass	1.3	0.9	-0.4
	Voghji River Basin		
Kajaran	1.6	2.1	0.5
Kapan	6.2	6.6	0.4
	Meghriget River Basin		
Meghri	9.4	10.2	0.8

Changes in atmospheric precipitation: Systematic observations conducted in the Southern BMA show that precipitations tend to decrease by an average of 13% (Figure 3.1). In particular, atmospheric precipitations have decreased at almost all meteorological stations by 6-23%, with the exception of Sisian station, where precipitation has a slight upward trend (Table 3.1).

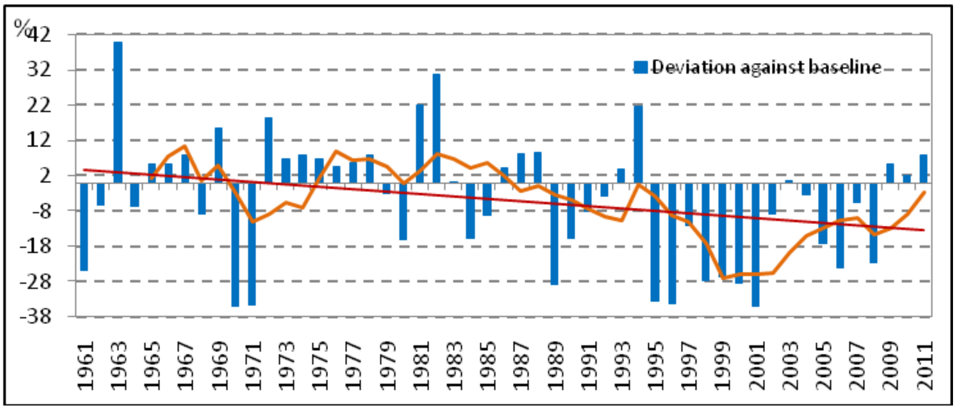


Figure 3.3: Deviations of annual atmospheric precipitation values against the baseline average for 1961-1990 in the Southern BMA

Table 3.4: Deviations of annual atmospheric precipitation values in the period of 1991-2011 against the baseline average for 1961-1990 in the Southern BMA

Meteorological station	*1961-1990(mm)*	*1991-2011 (mm)*	*Deviation, mm/%*	
	Vorotan River Basin			
Goris	759.0	711.3	-47.7	-6.3%
Sisian	380.9	406.3	25.4	+6.7%
Vorotan Pass	718.3	554.6	-163.7	-22.8%
	Voghji River Basin			
Kajaran	654. 0	534.6	-119.4	-18.3%
Kapan	589. 4	530.9	-58.6	-9.9%
	Meghriget River Basin			
Meghri	290.6	267.8	-22.8	-7.8%

According to analysis results, decreasing trend of atmospheric precipitation by about 0.4-32.8% was observed during all seasons and at all meteorological stations of the Southern BMA during 1991-2011. The highest deviations from the norm have been observed at Vorotan Pass and Kajaran stations during spring and summer months by about 17-33%. Overall, precipitation decreased by 13% during summer months on the average, by 9% during the months of spring and fall, and by 10% during winter. An annual increase in precipitation by about 7% was observed solely in Sisian station (Figure 3.4).

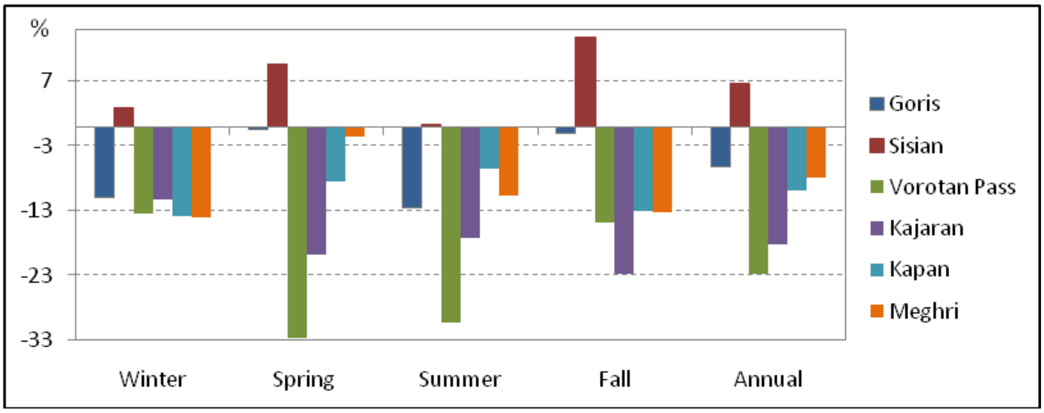


Figure 3.4: Deviations of atmospheric precipitation quantities in the period of 1991-2011 against the baseline average values for 1961-1990

Precipitation in the form of snow: Systematic observations conducted in the Southern BMA show that precipitations in the form of snow tend to decrease by an average of 23% (Figure 3.4). In particular, precipitation in the form of snow has decreased by 10% in the Vorotan River Basin, except for Sisian region, by 25% in the Voghji River Basin and by about 55% in the Meghriget River Basin (Table 3.5).

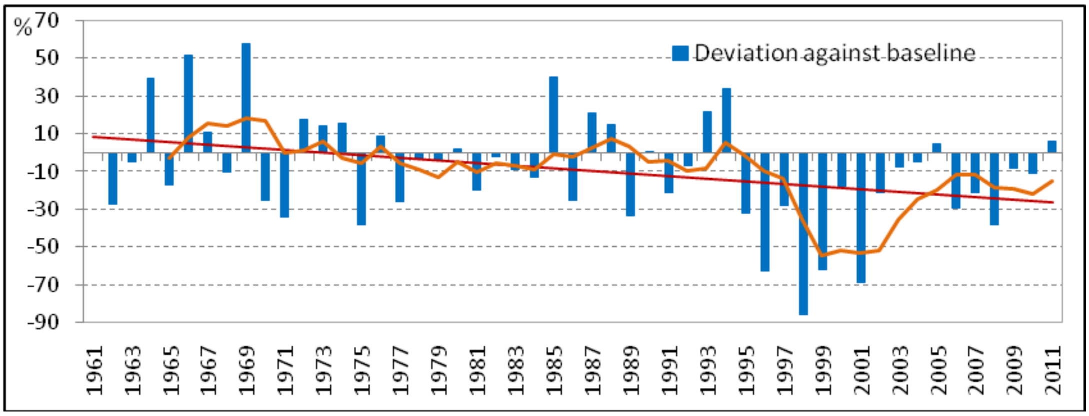


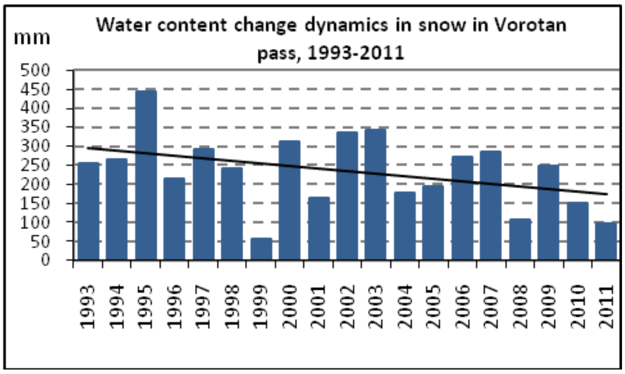
Figure 3.5: Deviations of atmospheric precipitation in the form of snow against the baseline average values for 1961-1990 in the Southern BMA

Table 3.5: Deviations of atmospheric precipitation quantities in the form of snow in the period of 1991-2011 against the baseline average values for 1961-1990 in the Southern BMA

Meteorological station	***1961-1990(mm)***	***1991-2011 (mm)***	***Deviation, mm/%***	
Vorotan River Basin				
Goris	175.2	148.9	-26.3	-15.0
Sisian	68.4	70.0	+1.6	+2.4
Vorotan Pass	322.7	265.6	-57.1	-17.7
Voghji River Basin				
Kajaran	223.6	189.7	-33.9	-15.2
Kapan	52.4	34.7	-17.7	-33.7
Meghriget River Basin				
Meghri	17.5	7.9	-9.6	-54.8

Water content in snow: Snowmelt is essential for river flow formation in the Southern BMA, thus dynamics of changes in water content in snow was also studied during assessment of climate change trends. However, the insufficiency of snow measurement data did not make it possible to carry out study of changes in water content in snow for the entire Southern BMA. The study incorporated only analysis of data for the Vorotan Pass and Kajaran meteorological stations for the period of 1980-2011.

In particular, the first ten-day period of March of each year was considered as the representative period for snowmelt in the basin. According to analysis results, a decreasing trend of water content in snow by 27.5% is observed in the Vorotan and Voghji River Basins (Figure 3.6).



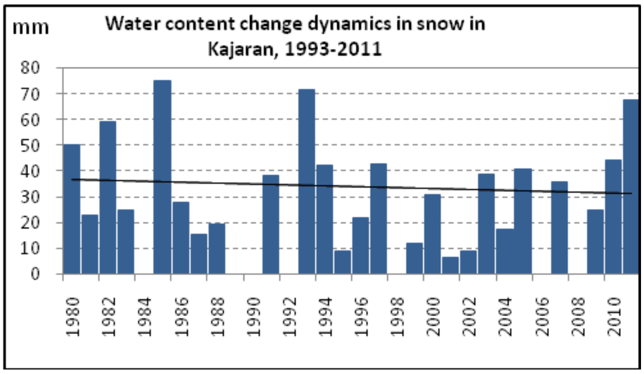


Figure 3.6: Changing dynamics of water content in snow during the period of 1980-2011 in the Southern BMA

Other climatic elements, including wind speed and direction, relative humidity, dangerous hydro-meteorological phenomena, as well as analyses of climate extreme indices are presented in Annexes C1-C4.

3.2.2. Observed Trends in Natural Flow of Rivers

In order to assess the impacts of climate change on the river flow in the Southern BMA, natural flow of rivers was restored and dynamics of changes were evaluated for 1991-2011 against the baseline average values.

Time series of natural flow data were restored based on actual flow measured in the hydrological observations points of the Southern BMA, as well as water use volumes and quantity of water transferred from one basin to the other, based on ArmstateHydromet Service's archived data for 1961-1995 and water use permits data issued by the WRMA of the RA MNP during 2003-2012. In addition, data provided by currently operational 9 observation points, as well as currently inactive 5 other observation points, which ensure availability of data time-series for 25 or more years, have been used in the analyses (Figure 3.6 and Table 3.6).

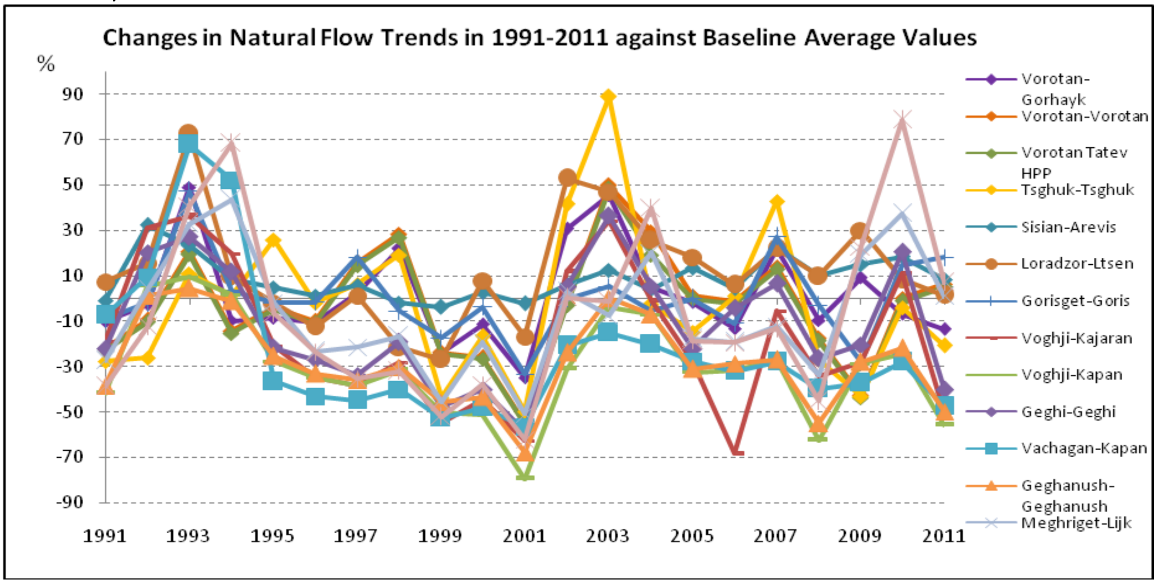


Figure 3.7: Deviations of annual average values of natural flow in the observation points of the Southern BMA against the baseline average values for 1961-1990

Table 3.6: Multi-annual average values of natural flow and their deviations against baseline average values for 1961-1990 in the Southern BMA

River-Hydrological observation point	*Time- series, years*	*1961-1990, million m^3*	*1991-2011, million m^3*	*Deviation*	
				million m^3	*%*
Vorotan River Basin					
Vorotan-Gorhayk	25 /1988-to present/	492	499	7	1
Vorotan-Vorotan	62 /1951-to present/	378	367	-11	-3
Vorotan-Tatev HPP	45 /1968-to present/	336	321	-15	-4
Tsghuk -Tsghuk	25 /1988-to present/	614	602	-12	-2
Gorisget-Goris	46 /1967-to present/	310	311	2	1
Sisian-Arevis	25 /1963-1988/	208	227	18	9
Loradzor-Ltsen	47 /1934-1981/	110	124	13	12
Voghji River Basin					
Voghji–Kajaran	51 /1961-to present/	114	94	-20	-18
Geghi–Geghi	27 /1961-1988/	154	141	-13	-8
Geghanush –Geghanush	26 /1961-1987/	20	14	-6	-28
Vachagan –Kapan	38 /1965-1994, 2003-to present/	16	12	-4	-24
Voghji–Kapan	37 /1965-1991, 2001-to present/	388	269	-119	-31
Meghriget River Basin					
Meghriget–Meghri	51 /1961-to present/	103	96	-7	-6,6
Meghriget–Lichk	40 /1961-2001/	20	19	-1	-6,4

The analysis of the above-mentioned data time-series shows that annual natural flow decreased at all observation points of the Voghji and Meghriget River Basins during 1991-2011 by 6-31%, which is mainly due to reduction of annual atmospheric precipitation by 8-18% in the selected river basins.

Decrease in natural flow by 1-3% is also observed in the upstream and middle streams of the Vorotan River Basin due to increased temperature and decreased rates of precipitation in the basin during the same time period, whereas, an increase in natural flow by 1-3% is observed in the lower streams of the same river basin which is mainly conditioned by availability of forests in this area and lower rates of evaporation.

Analysis of seasonal flow patterns was carried out only in the observation points of the Voghji and Meghriget River Basins due to insufficient seasonal data on natural flow for the entire Southern BMA. According to the analysis of seasonal data, decrease in natural river flow was observed during all seasons in the period of 1991-2011 in almost all observation points as compared to baseline average values for 1961-1990.

Table 3.7: Deviations of natural flow for the period of 1991-2011 against the baseline average values, %

Meteorological station	*Winter*	*Spring*	*Summer*	*Fall*
Voghji River Basin				
Voghji–Kajaran	-44.4	-7.4	-14.9	**-52.1**
Geghi–Geghi	-21.6	2.4	-6.8	**-33.9**
Geghanush –Geghanush	-34.8	-**47.3**	19.8	-19.1
Vachagan –Kapan	-17.1	-28.9	-6.9	**-37.6**
Voghji–Kapan	-27.5	-25.5	-**36.2**	-29.1
Meghriget River Basin				
Meghriget-Meghri	-5.1	-2.2	-8.0	**-19.9**
Meghriget-Lichk	-17.8	3.1	-7.6	**-23.8**

In particular, the highest decreases in natural flow was observed in the Voghji-Kajaran, Geghi -Geghi and Vachagan-Kapan observation points in the fall by 34-52%, which is due to the reduction of atmospheric precipitation in the river basin in this period of the year. The natural flow in the Geghanush-Geghanush observation point decreased most (by 47.3%)in spring, conditioned by high winter temperature and decreased atmospheric precipitation, including precipitation in the form of snow, and while the maximum decrease of natural flow at Voghji-Kapan observation point was observed in the summer (36.2%) which due to decrease in precipitation and increase in temperature and evaporation intensity. At Meghriget-Meghri and Meghriget-Lichk observation points the highest decrease in natural flow by 20% and 24% respectively was observed in the fall due to the decrease in precipitation quantities during this season.

On the other hand, an increase in natural flow was observed at two observation points in the Voghji and Meghriget River Basins. In particular, the natural flow increased in spring at Geghi-Geghi and Meghriget-Lichk observation points by 2.4% and 3.1% respectively, due to high temperatures and increase in surface runoff resulting from snowmelt, as well as in summer at Geghanush -Geghanush observation point by 20% due to availability of forests in this area and lower level of evaporation in this part of the river basin.

3.2.3. Climate Change Projections

Climate change projections for the Southern BMA were produced by the PRECIS regional climate modeling system, which is based on the third generation climate model (HadRM3), developed by the United Kingdom's Meteorological Office Hedley Center. Observed data for temperature and precipitation for the period of 1961-1990 were first used to calibrate the PRECIS model, and further empiric-statistical methods were applied for downscaling the model results. The HadRM3 uses output data of global climate models (GCMs) and performs a dynamic downscaling in order to acquire regional scale climate projections with a spatial resolution of 0.22^0x 0.22^0 (25 x 25 km).

Air temperature: The comparison of monthly average air temperature values simulated by PRECIS model for the baseline period of 1961-1990 and systematic observations data indicate that the model captures the annual cycle of temperature well enough, whereas monthly air temperature values are underestimated, particularly during the summer and winter months. The projection results of annual and seasonal average air temperature values for the Southern BMA generated through downscaling of climate data according to SRES A2 and B1 emission scenarios are provided in Table 3.8.

Table 3.8: Deviations in annual and seasonal average air temperature (^{0}C) in the Southern BMA against the baseline average values for 1961-1990, under IPCC A2 and B1 scenarios

Winter		*Spring*		*Summer*		*Fall*		*Annual*	
A2	**B1**	**A2**	**B1**	**A2**	**B1**	**A2**	**B1**	**A2**	**B1**
2040									
0.2	0.1	1.1	0.8	1.6	1.2	1.0	0.9	**1.0**	**0.7**
2070									
0.7	0.3	1.9	1.4	3.2	2.4	2.2	1.4	**2.0**	**1.4**
2100									
1.1	0.6	2.9	2.3	5.3	4.4	3.5	2.4	**3.2**	**2.4**

According to the results, the average annual air temperature is projected to continuously increase during all the seasons across the Southern BMA against the baseline average values by 0.7-1.0°C through 2011-2040, 1.4-2.0°C by 2041-2070 and 2.4-3.2°C by 2071-2100 (according to B1 and A2 scenarios, respectively).On seasonal basis, the maximum temperature increase is projected to occur during the summer months by up to 5.3°C in 2100 under IPCC A2 scenario.

Below the seasonal and annual average air temperature values are presented for baseline and projected periods per altitudes.

Table 3.9: Seasonal and annual average air temperature values (°C) for the baseline period of 1961-1990 in the Southern BMA, by altitude

Absolute altitude, m	*Winter*	*Spring*	*Summer*	*Fall*	*Annual*
500	6.1	13.7	23.6	15.7	14.8
800	4.2	11.8	21.7	13.8	12.9
1100	2.3	9.9	19.8	11.9	11.0
1400	0.4	8.0	17.9	10.0	9.1
1700	-1.5	6.1	16.0	8.1	7.2

Absolute altitude, m	Winter	Spring	Summer	Fall	Annual
2000	-3.4	4.2	14.1	6.2	5.3
2300	-5.3	2.3	12.2	4.3	3.4
2600	-7.2	0.4	10.3	2.4	1.5
2900	-9.1	-1.5	8.4	0.5	-0.4

Table 3.10: Projected changes in seasonal and annual average air temperature (°C) in the Southern BMA, under IPCC A2 scenario, by altitude

Absolute altitude, m	Winter			Spring			Summer			Fall			Annual		
	2040	2070	2100	2040	2070	2100	2030	2070	2100	2040	2070	2100	2040	2070	2100
500	6.3	6.8	7.2	14.8	15.6	16.6	25.2	26.8	28.9	16.7	17.7	19.2	15.8	16.7	18.0
800	4.4	4.9	5.3	12.9	13.7	14.7	23.3	24.9	27.0	14.8	15.8	17.3	13.9	14.8	16.1
1100	2.5	3.0	3.4	11.0	11.8	12.8	21.4	23.0	25.1	12.9	13.9	15.4	12.0	12.9	14.2
1400	0.6	1.1	1.5	9.1	9.9	10.9	19.5	21.1	23.2	11.0	12.0	13.5	10.1	11.0	12.3
1700	-1.4	-0.9	-0.5	7.2	8.0	9.0	17.6	19.2	21.3	9.1	10.1	11.6	8.2	9.1	10.4
2000	-3.3	-2.8	-2.4	5.3	6.1	7.1	15.7	17.3	19.4	7.2	8.2	9.7	6.3	7.2	8.5
2300	-5.2	-4.7	-4.3	3.4	4.2	5.2	13.8	15.4	17.5	5.3	6.3	7.8	4.4	5.3	6.6
2600	-7.1	-6.6	-6.2	1.5	2.3	3.3	11.9	13.5	15.6	3.4	4.4	5.9	2.5	3.4	4.7
2900	-9.0	-8.5	-8.1	-0.4	0.4	1.4	10.0	11.6	13.7	1.5	2.5	4.0	0.6	1.5	2.8

The spatial distribution of average annual air temperature in the Southern BMA for 1961-1990 and for projected periods of 2011-2040, 2041-2070 and 2071-2100 were generated through physical-statistical interpolation method for A2 and B1 emission scenarios of IPCC (Annex C5).

Precipitation: The comparison of precipitation values generated by PRECIS regional model for 1961-1990 baseline period with systematic observations data reveals that the model precisely estimates the annual cycle of precipitation in the Southern BMA, whereas observed monthly precipitation values are overestimated throughout the year.

According to the annual precipitation trend, the maximum precipitation occurs during the months of April-June, while the summer (July-September) and winter (January-February) months are characterized by precipitation scarcity.

The projected deviation of annual and seasonal precipitation values against the average for the baseline period of 1961-1990, under IPCC A2 and B1 emission scenarios, are presented in Table 3.11.

Table 3.11: Deviation of seasonal and annual precipitation values (%) against the baseline average for 1961-1990in the Southern BMA, under IPCC A2 and B1 scenarios

Winter		Spring		Summer		Fall		Annual	
A2	B1	A2	B1	A2	B1	A2	B1	**A2**	**B1**
2040									
7	5	4	3	2	1	9	10	**6**	**5**
2070									
10	9	8	6	7	7	13	14	**10**	**9**
2100									
15	13	10	7	7	7	19	15	**14**	**11**

According to the analysis results, an increase in annual precipitation in the Southern BMA by 11-14% before 2100 is projected under IPCC B1 and A2 emission scenarios, respectively.

It should be noted that there are some uncertainties related with projection of precipitation, due to natural variation of precipitation quantity and the model itself.

Precipitation is particularly projected to increase during fall and winter periods, and relatively insignificant positive changes will be observed during spring and summer periods. Such changes in precipitation and temperature patterns may intensify and increase the frequency of floods and inundations in the basin.

The deviation of annual precipitation in the Southern BMA for 2011-2040, 2041-2070 and 2071-2100 against the average values of the baseline period are provided in Annex C6.

3.2.4. Climate Change Impacts on the Water Resources of the Southern BMA

The vulnerability of water resources of to climate change was assessed by application of the physical-statistical regression modeling approach. Based on this, correlations between multi-annual observation data for precipitation and temperature recorded at hydrometeorological stations and the natural river flow at Southern BMA rivers were established, and the projected changes in the natural flow against the baseline average values were assessed under climate change scenarios (Table 3.12).

Table 3.12: Modeled annual natural river flow values at hydrological stations of the Southern BMA for short- and long-term horizons, under IPCC A2 scenario

River-Hydrological observation point	Baseline period	Modeled natural low, million m^3								
		Short-term(for the next 6 years, according to the BMP cycles)						Long-term		
	1961-1990	2016	2017	2018	2019	2020	2021	2040	2070	2100
Vorotan River Basin										
Vorotan-Gorhayk	**132.0**	135.1	135.2	135.3	135.4	135.6	135.7	137.9	145.0	152.8
Tsghuk -Tsghuk	**83.5**	84.9	84.9	85.0	85.0	85.1	85.1	86.1	89.0	92.2
Sisian-Arevis	**24.6**	24.9	24.9	24.9	24.9	25.0	25.0	25.2	26.1	27.2
Loradzor-Ltsen	**13.0**	12.8	12.8	12.8	12.8	12.8	12.8	12.7	12.3	11.9
Vorotan-Vorotan	**585.3**	582.9	582.8	582.7	582.6	582.5	582.4	580.6	571.6	559.7
Vorotan-Tatev HPP	**672.8**	666.0	665.8	665.5	665.3	665.0	664.7	659.8	638.7	612.1
Gorisget-Goris	**20.1**	20.0	20.0	19.9	19.9	19.9	19.9	19.8	19.3	18.6
Voghji River Basin										
Voghji–Kajaran	**113.9**	109.0	108.8	108.6	108.4	108.2	108.0	104.5	96.5	84.8
Geghi–Geghi	**159.5**	155.1	155.0	154.8	154.6	154.5	154.3	151.1	143.4	130.7
Vachagan–Kapan	**15.7**	15.1	15.0	15.0	15.0	15.0	14.9	14.5	13.5	12.1
Geghanush-Geghanush	**19.6**	19.0	18.9	18.9	18.9	18.9	18.9	18.4	17.3	15.5
Voghji–Kapan	**388.4**	374.0	373.5	372.9	372.4	371.8	371.3	360.8	337.9	306.5
Meghriget River Basin										
Meghriget–Meghri	**102.9**	98.4	98.2	98.0	97.9	97.7	97.5	94.2	86.7	75.2
Meghriget–Lichk	**20.4**	19.4	19.4	19.4	19.3	19.3	19.3	18.6	17.1	15.1

Graphical illustrations and spatial maps of the simulated annual natural river flow in the Southern BMA are provided in Annexes C7 and C9, respectively. Seasonal natural river flow under climate change scenarios was simulated for the Voghji and Meghriget River Basins only due to lack of monthly natural river flow data time-series for the entire Southern BMA.

According to modeling results for the seasonal natural river flow, under IPCC A2 scenario, a decrease by 5-9%, 10-16% and 17-27% respectively for 2040, 2070 and 2100 is projected during all seasons at all observation points of the above-mentioned river basins.

The modeled seasonal river flow in the Voghji and Meghriget River Basins for 2040, 2070 and 2100, under IPCC A2 scenario, is provided in Annex C8.

3.2.5. Climate Change Impact on the Quality of Water Resources in the Southern BMA

Local hydro-meteorological conditions have significant impact on shaping of hydro-chemical regime of the Southern BMA rivers. Since the Southern BMA rivers are mountainous, fast flowing and with small and medium water abundance levels, any climate-related change inevitably impacts the water quality of rivers resulting in natural changes in hydro-chemical parameters.

Therefore, an assessment of changes in hydro-chemical quality of water resources due to climate change was conducted for the rivers of the Southern BMA. The assessment is based on the data of annual reports of the EIMC of the RA MNP and the Hydromet Service of the RA MTAES, covering the periods of 1982-1990 and 2007-2013.

The assessment was conducted for the observations points located in the river heads, where anthropogenic impact on the water quality is absent or minimum. These observation points include: Vorotan-Gorhayk for the Vorotan River, the observation point located upstream the Arevis village for the Sisian River, the observation point located upstream the Kajaran town for the Voghji River, Geghi-Geghi observation point for the Geghi River, and the observation point near the Lichk village for the Meghriget River. The assessment has not been possible to be conducted for other rivers in the Southern BMA due to insufficient data.

Oxygen regime (Dissolved oxygen, BOD5) and mineralization (main ions, ions sum, hardness) elements concentration changes over the period of 2007-2013 were analyzed for assessing the impacts of climate change on water quality of the Southern BMA rivers. The period of 1982-1990 was chosen as baseline. The differences of analytical methods were taken into account when comparing the concentrations of selected hydro-chemical parameters.

The assessment results are presented in Table 3.13.

Table 3.13: Deviation of average values of concentration of hydrochemical parameters for the period of 2007-2013 observed in the Southern BMA rivers against the baseline average values for 1982-1990

Hydrochemical parameters	*Vorotan-Gorhayk*	*Sisian- Arevis*	*Voghji-Kajaran*	*Geghi-Geghi*	*Meghriget-Lichk*
Oxygen regime					
Dissolved oxygen (mg/l)	Not observed	Not observed	Not observed	Not observed	Not observed
Biochemical oxygen demand(BOD5) (mg O/l)	Not observed	Not observed	Not observed	Not observed	7.3%
Mineralization					
Hardness (mg eq/l)	Not observed	-42.7%	Not observed	Not observed	Not observed
The sum of main ions (mg/l)	-7.1%	-3.5%	9.0	Not observed	6.7%
Sulphate ion (mg/l)	13.0%	-15.2%	6.7	9.2	Not observed
Hydrocarbonate ion (mg/l)	-4.7%	-25.6%	17.7	Not observed	Not observed
Chloride ion (mg/l)	-42.0%	-35.4%	11.2	30.2	Not observed
Calcium ion (mg/l)	24.4%	-42.2%	Not observed	-43.6	Not observed
Magnesium ion (mg/l)	-28.0%	Not observed	Not observed	18.9	Not observed
The sum of Sodium and Potassium ions (mg/l)	-29.0%	-34.1%	10.5	14.3	6.8%

According to the results, natural pressures on the water quality of rivers in the Southern BMA are insignificant and are compensated by natural adaptation processes occurring in the basin.

No significant changes in oxygen regime in the Vorotan, Sisian, Voghji, Geghi and Meghriget Rivers were observed during the period of 2007-2013 against the 1982-1990 baseline average, with the exception of Meghriget River where a slight deviation in the form of increase in BOD values by 7.3% was observed.

Some concentration deviations of elements of mineralization regime were observed in the same period. Deviations of main ions concentrations were most obvious especially in the Vorotan, Sisian and Geghi Rivers with predominantly decreasing trend of concentration of main ions (by approximately 25%) against the baseline average values. The highest deviation from baseline average values was observed in calcium concentrations, by up to -43.6%.

Annual deviations of concentrations of mineralization elements against the baseline average values at reference observation points of the Vorotan, Sisian, Voghji, Geghi and Meghriget Rivers of the Southern BMA are conditioned by changes in precipitation and river flow. The decrease in precipitation by 23% at

Vorotan-Gorhayk observation point of the Vorotan River in the Vorotan River Basin has resulted in increase of sulphate and calcium ion concentrations and decrease in other mineral elements. On the other hand, increase in precipitation and river flow by 9% and 6.7% respectively at Sisian-Arevis observation point of the Sisian River has resulted in reduction of mineralization of river water.

Due to the decrease in precipitation and river flow by 18% at Voghji-Kajaran observation point of the Voghji River, the concentrations of anions have increased. On the other hand, decrease in precipitation and river flow by 18% and 8% respectively at Geghi-Geghi observation point of Geghi River has resulted mainly in changes of cations.

Precipitation and river flow decrease by 8% and 6.4%, respectively in the observation point near the Lichk village of the Meghriget River has resulted in increase of only sodium and potassium concentrations by 6.8%.

The occurrence of changes in concentrations of mineralization elements of river waters compensate one another, resulting in insignificant water quality changes. Decrease in mineralization pattern is observed only in case of Sisian River which will not pose serious problems for the aquatic ecosystem.

3.3. Anthropogenic Impact Assessment

Economic activities impact the quality and quantity of both the natural environment and water resources. Mining industry with its mines, tailing dams and other infrastructure, communal wastewater, return flows from industry and agriculture are having significant impact on the quality and regime of water resources in the Southern BMA. Water demand is increasing in the Southern BMA every year, which affects both the natural fluctuations of quantity of water resources (especially during low-flow years) and water quality.

In order to assess anthropogenic impacts on water resources in the Southern BMA, point and diffuse pollution sources were analyzed and assessed.

Main diffuse/non-point sources of water pollution in the Southern BMA include:

- Mining: mines and waste dumps in the river basins of the Southern BMA;
- Return flows from agricultural farmlands throughout the Southern BMA;
- Return flows from non-food industry, including car wash services;
- Decentralized wastewater disposal and household waste removal in the rural communities throughout the Southern BMA;
- Livestock breeding farms throughout the Southern BMA:
- Roads, including the Iran-Armenia interstate highway, as well as the republican and intercommunity roads that pass along the rivers:
- Eroded lands in the areas adjacent to the settlements, reservoirs and river floodplains of the Southern BMA.

Main point sources of water pollution in the Southern BMA include:

- Communal wastewater of the Kapan, Kajaran, Goris, Sisian, Meghri and Agarak towns;
- Mining industry waste: waste dumps (Zangezur Copper-Molybdenum Combine, Dundee Precious Metals, Ler-Ex, Agarak Copper-Molybdenum Combine and others);
- Return flows of the mining industry;
- Tailing dams, including operational (Artsvanik, Geghanush, Geghi, Darazami, Hovit 1 and Hovit 2) and reclaimed (Voghji, Pkhrut and Dastakert).

Human activities also alter hydrological regime of the rivers and the correlation of water balance elements. Hydrographs of the Vorotan-Angeghakot observation point before construction of the Spandaryan reservoir and after its exploitation are shown in Figure 3.8.

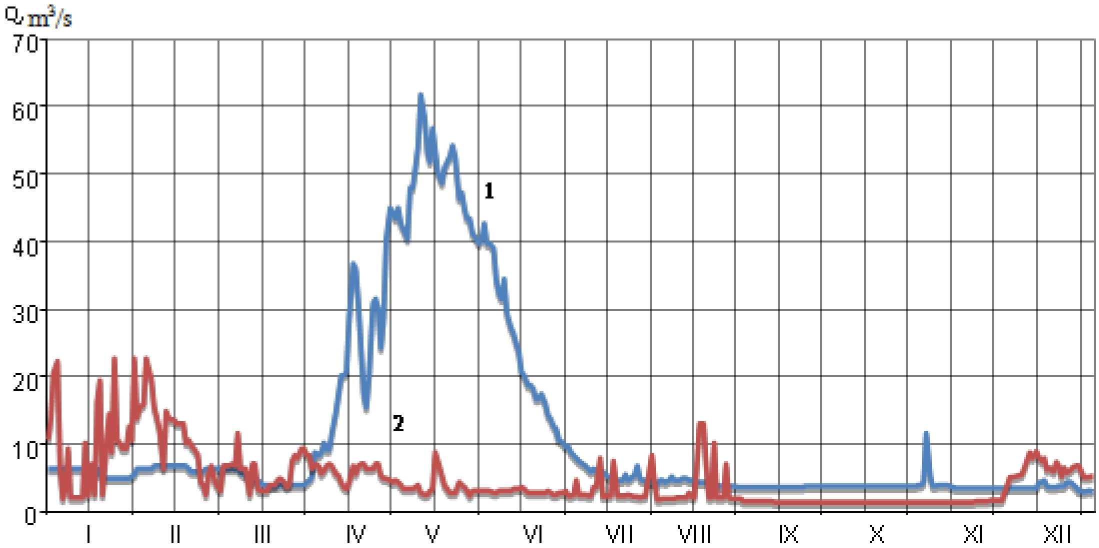


Figure 3.8: Hydrographs of the Vorotan-Angeghakot observation point before construction of the Spandaryan reservoir (1987) (1) and after its exploitation (1992)

As shown on Figure 3.8, regime of the river is uniform throughout the year after exploitation of the reservoir. There are no high flows appearing during flood period, while river flow during the low-flow winter period (separate days during December-February) is larger due to water releases from the reservoir for hydropower generation.

Multi-year natural and actual flows for hydrological seasons were determined and compared to assess changes in the water regime of the major rivers and their tributaries in the Southern BMA (Table 3.14).

Table 3.14: Seasonal distribution of river flow in the rivers of the Southern BMA and their tributaries

River-observation point	*Area of the river basin, km^2*	*Natural flow, %*			*Actual flow, %*		
		III-VI*	***VII-XI***	***XII-II***	***III-VI***	***VII-XI***	***XII-II***
Vorotan-Tatev HPP	1988	59.9	27.3	12.8	33.0	38.8	**28.2**
Tsghuk -Tsghuk	136	66.7	21.9	11.4	74.6	14.0	**11.4**
Gorisget-Goris	84.8	44.0	36.8	19.2	46.7	30.0	**23.3**
Tatev -Tatev	84.5	63.2	26.1	10.7	65.0	24.6	**10.4**
Voghji - t. Kajaran	120.0	60.5	32.1	7.3	61.9	32.0	**6.0**
Voghji - t. Kapan	710.0	64.0	26.3	9.7	66.3	24.9	**8.9**
Geghi – Geghi	195.0	63.6	25.2	10.9	60.0	28.3	**11.7**
Vachagan –t. Kapan	35.0	61.5	22.8	15.3	64.8	19.3	**15.9**
Meghriget-Lichk	21.0	59.9	34.0	6.2	60.4	33.8	**5.8**
Meghriget-Meghri	**274**	**64.4**	**24.7**	**10.9**	**67.5**	**21.4**	**11.1**

**III-VI – spring high-flow season extending from March to June, VII-XI – summer-autumn low-flow season extending from July to November, XII-II – winter low-flow season extending from December to February*

The Table 3.14 shows that the actual flow changes in relation to the natural flow in the rivers of the Southern BMA are more noticeable for the Vorotan River. The actual flow increased by 11.5% as compared to the natural flow during summer-autumn period in the Vorotan-Tatev hydrological monitoring points. The natural spring flow has in the same time decreased by 27%. The actual flow observed at all hydrological monitoring points of the Voghji River and its tributaries differs from the natural flow by 0.1 - 3.5% for all seasons, as there is a little regulation of the Voghji River flow. River flow regime changes are explained by water accumulation in reservoirs during spring period and water releases from the reservoirs during low-flow seasons for hydropower generation and irrigation.

Inter-basin water transfers are also affecting water regime in the rivers. The Vorotan-Arpa tunnel was put into operation in 2005. It is designed to take 165 million m^3 of water from the Spandaryan Reservoir and transport 100 million m^3 to the Lake Sevan via Arpa-Sevan tunnel and use the remaining 65 millionm^3 water in the Arpa River Basin for irrigation purposes. *Inter-basin water transfer has no significant pressure on the rivers flow in the Southern BMA, as it is done from the usable volume of the river flow.*

Urbanization level in the river basins of the Southern BMA is estimated to be low with exception of Kapan, Kajaran, Sisian and Goris towns, where it is observed to be at average level. ***Pressure from urbanization on water resources in the Southern BMA is insignificant.***

3.3.1. Identification of Pressures and Impact Assessment

According to the requirements of WFD Article 5, in order to identify pressures, data on significant anthropogenic pressure types and extent of such pressures in the Southern BMA were collected, analyzed and categorized. Pressure identification was performed according to the following sources and types of pressures:

1) Water abstraction for drinking-household purposes,
2) Water abstraction for irrigation purposes,
3) Water abstraction for industrial purposes,
4) Communal wastewater discharge, including wastewater pits,
5) Wastewater discharge from food industry,
6) Wastewater discharge from non-food industry,
7) Wastewater discharge from mining industry and mines,
8) HPPs,
9) Fisheries,
10) Agricultural crops and use of fertilizers,
11) Livestock breeding and overgrazing,
12) Forest logging,
13) Vehicular transport,
14) Solid wastes,
15) Tailing dams/ponds.

The pressures which have significant impact on separate sections of the rivers of the Southern BMA were identified and characterized in the result of analyses.

1) Water abstraction for drinking-household purposes: According to the WUPs, water use for drinking-household purposes in the Southern BMA amounted to 57.7 million m^3, as of January 2014, including 55.4 million m^3 supplied by South-Eastern Branch of the Armenian Water and Sewerage Company and 2.1 million m^3 supplied by communities.

A significant part of the drinking water supply system of all settlements of the Southern BMA have been constructed over 40-50 years ago, which are partially deteriorated. Water supply systems are operated without proper zoning with the exception of Sisian town. Daily regulation reservoirs (DRR) are in need of renovation and equipping. The level of drinking water treatment and disinfection is insufficient.

Sixty percent of drinking water supply network of the Goris town, as well as networks of 14 communities of the Southern BMA were repaired as of January 2014.

The actual water losses in the drinking water supply network of the Southern BMA made up 73% during the same period, leading to activation of landslides and collapses, as well as shortage of drinking water during summer months. The Armenian Water and Sewerage Company constructed a new water supply network during 2010-2011 which resulted in the reduction of water losses (actual water losses comprise 20-30%).

Investments made by the Armenian Water and Sewerage Company for the renovation and modernization of the water supply systems still do not provide an adequate level of service. Despite the economic damages caused by water losses, water use for drinking-municipal purposes does not disturb ecological state of the Southern BMA's water resources and **do not have significant pressure on water resources. Water use for drinking-household purpose comprises only 3-5% of the total water availability in the Southern BMA.**

2) Water abstraction for irrigation purposes: According to the WUPs, water use for irrigation purposes in the Southern BMA amounted to 43.732 million m^3, as of January 2014, which was implemented by the Sisian, Vorotan, Kapan and Meghri WUAs and self-supplied communities. Water losses make up about 40-50%, due to obsolete irrigation infrastructure and outdated irrigation methods. Irrigation infrastructure of the 16 pumping stations serviced by the Meghri WUA is old. Pumping stations along the Araks River are frequently flooded and damaged during high-water periods.

Although, water abstraction for irrigation purposes in the Southern BMA makes up about 2% of total water use in the basin, waters of the rivers are overused for irrigation during summer-autumn period. It leads to not maintenance of ecological flow in the middle and lower reaches of the Sisian and Gorisget Rivers of in the Vorotan River Basin.

Thus, water abstraction for irrigation purposes poses significant pressure on the quantity of water resources of the Sisian River - in the section stretching from Tasik settlement to Tolors Reservoir, and the Gorisget River in the section stretching from the Brun settlement to the border of Armenia.

Water abstraction for industrial purposes: According to WUPs, water use for industrial purposes in the Southern BMA amounted to 79.19 million m^3, as of January 2014, including 63.34 million m^3 in the Voghji and 13.88 million m^3 in the Meghriget River Basins. Water abstraction for industrial purposes was very limited in the Vorotan River Basin, comprising 0.27 million m^3.

In the Meghriget River Basin, 85.0% of water was abstracted by the Agarak Copper-Molybdenum Combine from groundwater resources (Agarak deep wells) to be used for industrial purposes. Water abstraction from groundwater resources in the Meghriget River Basin made up only 45% of usable the groundwater resources, which are estimated at 28.35 million m^3 annually, and has mainly been used for industrial purposes.

Based on the abovementioned, it can be concluded that ***water abstraction for industrial purposes does not pose significant pressure on quantity of water resources in the Meghriget River Basin.***

Due to a large-scale water abstraction by the Zangezur Copper-Molybdenum Combine, the ecological flow of the Voghji River is not maintained in the area of the Kajaran town.

Thus, water abstraction for industrial purposes poses significant pressure on quantity of water resources in the Voghji River Basin only.

4) Discharge of communal wastewater, including wastewater pits: Only Goris, Sisian, Kapan, Kajaran, Meghri and Agarak towns in the Southern BMA have centralized wastewater disposal systems, where the sewage is removed through centralized sewer networks and major collectors, ensuring 60-80% of sewage disposal from urban areas. As of January 2014, more than 60% of the sewer networks were in need of repair. These are old and were constructed 40-50 years ago resulting in occasional flooding of Agarak and sometimes Meghri town streets with sewage water. As of January 2014, the volume of urban sewage per annum amounted to about 8.0 million m^3, which, due to a lack of treatment plants, has been discharged into rivers, canals and drainage systems without treatment.
Residents of many villages in the Southern BMA use their own backyard wastewater pits due to lack of sewer network.

Neither sewage waters disposed through sewer system and nor communal wastewater discharged directly into open water basins are treated. These pose significant pressure on quality of water resources.

Impact of communal wastewaters is considered as point source pollution. The assessment of impact is based on volume of wastewater in relation to population size (Table 3.15).

Table 3.15: Pollutants concertation per population equivalent (p.e.)

Pollutant	***Daily output of pollutant quantity***
BOD_5	50-60 g/resident*day
$COD_{tot.}$	90 g/resident*day
Suspended particles	90 g/resident*day
Phosphorus	3 g/resident*day
$Nitrogen_{tot}$	15.5 g/resident*day
Ammonium	10.3 g/resident*day

According to the above values and based on the number of inhabitants, the pressure of communal wastewater on water resources quality was assessed the major towns in the Southern BMA. The calculation was carried out in two steps. The load BOD_5 in milligrams discharged per second was calculated as the first step:

A = 60 g/day * 1000 mg/g * (1/(24 hours/day * 60 minutes / hours * 60 sec / minutes)) * p.e. (population equivalent)

The growth of BOD_5 by mg/l under conditions of minimum flow was calculated for the second step.

A = (mg / sec)/ minimum flow (liter/sec).

The growth of the rest of the parameters was calculated using same approach (Table 3.16).

Table 3.16: Values of indicative parameters of the communal wastewater pressure of the towns in the Southern BMA

Settlement	***Population***	***COD_5 mg/l***	***$COD_{total.}$ mg/l***	***Suspended particles mg/l***	***Phosphorus mg/l***	***Nitrogen, mg/l***	***Ammonium ion, mg/l***
t. Sisian	16800	4.79	7.17	7.2	0.24	1.24	0.82
t. Goris	23100	58.3	87.46	87.5	2.92	15.06	10.01
t. Kajaran	7200	25.0	37.5	37.5	1.3	6.5	4.3
t. Kapan	43200	27.5	41.3	41.3	1.4	7.1	4.7
t. Meghri	4600	79.86	119.79	119.79	3.99	20.63	13.71
t. Agarak	4500	156.25	234.38	234.38	7.81	40.36	26.82

The values of indicative parameters were compared with relevant values defined by RA legislation and EU WFD guidance documents. For example, the marginal value of BOD5 is increase 1 mg/l. Hence, the pressure is considered essential, if BOD_5 increase exceeds 1 mg/l value.

According to estimates, BOD_5 increase exceeds the 1 mg/l value in the Sisian, Goris, Kajaran, Kapan, Meghri and Agarak towns.

Results of comparison of increase in values of other indicative parameters also confirm that communal wastewater poses significant pressure on quality of water resources in the Southern BMA. Particularly, the Vorotan river - from Sisian town to the Shamb Reservoir, the Gorisget River - from Goris town to the Republic of Armenia border, the Voghji River - from Kapan town to the river mouth, and the Karchevan River - from Agarak town to the river mouth.

According to results, maximum exceedance of increase of loads of BOD_5, ammonium ion and especially COD and suspended solids are observed near the Agarak town. High rates of actual increase of the COD load and suspended solids in the Agarak town are conditioned by both wastewater disposal of Agarak town and industrial wastewaters of the Agarak Copper-Molybdenum Combine. In this case, it is impossible to separate the impacts of communal wastewater on the Karchevan river quality form industrial impact by using values of actual increase of the COD load and suspended solids. The pressure of urban wastewater on river water quality was estimated by concentrations of the BOD_5 and ammonium ion. The increase of the BOD_5 load and ammonium ion in the river waters can only be conditioned by communal wastewater.

Besides this assessment approach, the calculated values of increased loads of the BOD_5, suspended solids, total nitrogen, ammonium and total phosphorus were compared with values of same parameters monitored in the reference sampling points of the EIMC. In addition, the projected concentrations of pollutants in the sections of the Voghji River in the Kajaran and Kapan towns were calculated at the control sampling points downstream the point sources of pollution (Table 3.17).

Table 3.17: Projected increase of values of water parameters at EIMC sampling posts in the Southern BMA

Description	*Concentration*					
	BOD_5, mg/l	*COD_{Cr}, mg/l*	*Suspended particles, mg/l*	*Phosphorus, mg/l*	*Nitrogen, mg/l*	*Ammonium ion, mg/l*
Background concentration values in the Vorotan River	3	10	4.6/5.5	0.08/0.2	0.271/4	0.39/0.40
Background concentration values in the Gorisget River	3	10	7.5/9	0.152/0.2	0.4/4	0.24/0.40
Background concentration values in the Voghji River	3	10	8.4/10.1	0.016/0.2	0.122/4	0.017/0.40
Background concentration values in the Meghriget and Karchevan Rivers	3	10	7.4/8.9	0.03/0.2	0.85/4	0.033/0.40
Actual increase (pressure) of pollutant concentration in the sampling point No 101 downstream the Sisian town	-0.39	5.36	4.95	0.02	0.61	0.34
Actual increase (pressure) of pollutant concentration in the sampling point No 107 downstream the Goris town	3.89	10.33	2.08	0.29	6.37	5.27
Actual increase (pressure) of pollutant concentration in the sampling point No 92 downstream the Kajaran town	2.77	11.16	14.79	0.22	5.97	5.31
Actual increase (pressure) of pollutant concentration in the sampling point No 94 downstream the Kapan town	1.22	6.16	16.51	0.01	0.59	0.51
Actual increase (pressure) of pollutant concentration in the sampling point No 90 downstream the Meghri town	0.10	1.75	4.95	0.04	0.52	0.16
Actual increase (pressure) of pollutant concentration in the sampling point No 344 downstream the Agarak town	7.90	342.35	5538.02	0.08	-0.15	1.96

The calculated data and water quality monitoring data show that communal wastewater poses significant pressure on quality of the Vorotan, Gorisget, Voghji and Karchevan rivers water quality - sections within the Sisian, Goris , Kajaran , Kapan and Agarak towns.

5) Discharge of wastewater from food industry: Food manufacturing enterprises are few in the Southern BMA and are mainly concentrated in Kapan, Goris, Sisian, Kajaran and Meghri towns. The predominating production branches are bread, dairy and meat productions. There are also canned food and mineral water productions. Relatively large food production factories in the Southern BMA are Elola dairy and cheese factories in Sisian and Verishen villages, canned food production factory of the Sisian and Meghri, Tatni drinking water bottling plant, the Kapan bread and Bareshen bread and bakery production enterprises, Lamaks Group, Syunik Poultry Farm and Vordi Spartak dairy, cheese and meat production enterprises. All listed enterprises have individual sewerage and are connected to urban sewerage.

Given the small scale of the food industry in the Southern BMA, and based on the above mentioned, **it is concluded that wastewater discharge from food has no significant pressure on quality of water resources in the basin.**

6) Discharge of wastewater from non-food industry: As of January 2014, there were a few non-food processing enterprises in the Southern BMA, with small volumes of water use and wastewater removal.

Relatively large non-food processing enterprises in the Southern BMA are the Sisian's Bau and VH Stone processing enterprises, Vaifl limestone production, Kapan forest enterprise - wood processing enterprise, Kapan Machinery vehicle's manufacturing and repair factory, as well as a number of smaller companies that produce furniture, clothing, etc., several gas stations, car wash and service centers. Small quantities of wastewater are discharged from the car wash and service centers.

Based on the abovementioned, wastewater discharge from non-food industry does not have significant pressure on the water quality of rivers in the Southern BMA.

7) Wastewater discharge from mining industry and mines:

7a) Wastewater discharge from mining industry: Mining areas in the Southern BMA are located in the Voghji and Meghriget River Basins. These are Dundee Precious Metals CJSC, Zangezur Copper-Molybdenum Combine CJSC, Agarak Copper-Molybdenum Combine CJSC and Ler-EX LLC. Wastewater from the mining industry is one of the pollution sources of Southern BMA water resources.

Wastewater systems of the copper-molybdenum combines are centralized, and the ore leaching tailings are transported to the tailings dams by pipelines. However, due to frequent pipeline leakages and breaks, tailings end up in the rivers and pollute waters.

Wastewaters from the mining industry in the Southern BMA pose significant pressure on quality of the rivers, particularly:

- *The Voghji River, from the Zangezur Copper-Molybdenum Combine to the border of the Republic of Armenia;*
- *The Geghi River, from the Ajabaj village to the Nor Astghaberd village;*
- *The Norashenik River, from wastewater pipeline of Artsvanik tailing dam to the river mouth;*
- *The Artsvanik River, from the tailing dam to river mouth;*
- *The Geghanush River, from the tailing dam to river mouth;*
- *The Tsakqar River, from confluence point of the Makanajur tributary to river mouth;*
- *The Kavart River entirely;*
- *The Darapi River entirely;*
- *The Karchevan River, from the Agarak* Copper-Molybdenum Combine *to the Araks River;*
- *The Meghriget River, from the Tkhkut village to the Vardanidzor village.*

Exploratory works were in process by the Geoteam CJSC for operation of the Amulsar Gold Mine in the Vorotan River Basin in 2014. According to the EIA for the Amulsar gold-bearing quartzite deposit (2012), it is planned to use water from the Vorotan River during the mine operation. Modern water use technologies are planned to be applied in the processes and the return flows will be treated before discharging into the Vorotan River. According to the environmental and social impact assessment for the Amulsar Gold Project from 2015, a number of measures will be implemented by the Lydian international during various phases of the project implementation to mitigate risks and impacts on water resources and ecosystems. No major water courses will be altered during implementation of the project. Lydian will adhere to the International Cyanide Management Code, which will ensure the safe transport, handling and use of cyanide at Amulsar gold mine.

There was no discharge of wastewater from the decommissioned Dastakert Copper-Molybdenum Combine in the Vorotan River Basin in 2014.

The Dastakert Copper-Molybdenum Mine is expected to be operated in the Vorotan River Basin, as well as the Lichk and Tashtun polymetallic mines in the Meghriget River Basin the near future. Feasibility study and technical design for exploration and exploitation of the mines were still being held as of January 2014.

7b) Mines: Exploitation of the mines in the Southern BMA has significant impact on quality of water resources. Main mines in the Southern BMA are: the Kajaran, Kapan and Hankasar Copper-Molybdenum deposits in the Voghji River Basin; the Agarak Copper-Molybdenum open mine and the Lichkvaz-Tey underground gold mine in the Meghriget River Basin, as well as 4 small quarries.

The Kajaran mine is near the Kajaran town, on the right bank of the Voghji River. It is operated by the Zangezur Copper-Molybdenum Combine CJSC and is considered to be the largest mine in the river basin.

The Shahumyan polymetallic open mine (about 23 ha) is near the Kapan town, in the Kavart River Basin. It is owned by the Dundee Precious Metals CJSC, and currently is not operated.

The Hankasar Copper-Molybdenum mine is in the catchment area of the Ajabaj Tributary to the Geghi River and is being exploited by Ler-Ex LLC. (Operations of the company were temporarily suspended as of September 2014).

The Agarak Copper-Molybdenum open mine occupying 432 ha area is between the Kuris and Karchevan villages in the Voghji River Basin. It is operated by the Agarak Copper-Molybdenum Combine CJSC, which is owned by the Kompas Industries Company. Mine produces about 2.7 million tons of ore annually.

The Lichkvaz-Tey gold and copper mine is near the Tkhkut village at the right bank of the Meghri River, 20 km away from the Meghri railway station. Exploitation license was acquired in November 2012 by the Sagamar CJSC, which is owned by the Global Metals Company. Operations were scheduled to be commencing during the second half of 2014. Due to geological conditions, it is designed to apply underground mining method, with 150-200 thousand tons of ore production annually.

According to data of the RA Ministry of Energy and Natural Resources, permits for extracting minerals were granted to the Tatstone LLC for operating the Lichk Copper mine (issued on 11.02.2013), 'Sisian-1 LLC for the Terterasar Gold mine (issued on 25.02.2013), Active Lernagorts LLC for the Aygedzor Copper-Molybdenum mine (issued on 28.12.2012) in 2013.

The Lichk Copper-Molybdenum mine is located in the upper streams of the Meghriget River, near the Lichk village. It is in the sanitary protection zone of the drinking water distribution system of the Meghri town and other settlements. Operation of the mine could result in both qualitative and quantitative impacts on the Meghriget River and drinking water supply system.

The Aygedzor Copper-Molybdenum deposit is near the Tkhkut village, extending on both sides of the Meghri River, on about 120 ha area. It is being operated by a conventional open method.

Surface runoff formed during snowmelt and spring high-water period in the territory of the mines discharges into the rivers and transports big loads of minerals and ore. The following river stretches are polluted in a result:

- *The Voghji River, from the Kajaran town to reclaimed Voghji tailing dam,*
- *The Voghji River, from the Shahumyan mine to the Republic of Armenia border,*
- *The Geghi River, from the Hankasar mine to Geghi village,*
- *The Meghriget River, near the Tkhkut village,*
- *The Karchevan River, from the Agarak Copper-Molybdenum mine to Araks river,*
- *The Meghriget River, from the Tkhkut village to Vardanidzor village.*

During the summer dry period, dust from the mines which is rich in copper, molybdenum, chromium, manganese and other heavy metals, is transported to nearby residential areas by wind, thus polluting the environment and posing high risks for human health.

Based on the above mentioned, exploitation of mines in the Southern BMA mines have significant pressure on the water quality.

The impact of the non-operational Dastakert mine and its tailing dam in the Vorotan River Basin can be considered together, due to the proximity of the mine and the tailing dam. The concentration of pollutants emerging with wash waters in the river basin cannot be separated. Therefore, the pressures of the non-operational mine and reclaimed tailing dams are assessed together and discussed in the section on the tailings dams.

8) HPPs: As of January 2014, water use for hydropower generation in the Southern BMA amounted to 2445.2 million m^3, including 76% in the Vorotan River Basin (1868.1 million m^3), 20% in the Voghji River Basin (485.8 million m^3) and 4% in the Meghriget River Basin (91.3 million m^3).

About 56.7% of water use for hydropower generation in the Southern BMA was by 3 large HPPs of the Vorotan HPP complex, and the rest by 35 operational SHPPs.

The ecological flow is not maintained in some stretches of rivers due to water abstraction by large and small HPPs, which have pressure on quantity of water resources in the river basins:

- ***The Vorotan River Basin:*** *the Vorotan river from the Spandaryan Reservoir to the Angeghakot Reservoir, as well as from the Shamb Reservoir to the Tatev HPP; the Sisian River form the Tolors Reservoir to river mouth, the Tsghuk River from water abstraction of the SHPP (at about 2550 m elevation) to the river mouth; the Shaqi River from the Shaqi SHPP to river mouth.*
- ***The Voghji River Basin:*** *the Voghji River from confluence with the Geghi River to the Kapan town.*
- ***The Meghriget river basin****: the Meghriget River from the Lichk village to the confluence of the Gozgoz tributary, from the Vardanidzor village to the Meghri town.*

At the time of preparing this report, a purchase-sale agreement on the Vorotan HPP Complex was signed between the GOA, the Vorotan HPP Complex, the Contour Global Hydro Cascade, the Contour Global Terra Holdings and CG Solutions Global Holding Company. It is planned to invest in the modernization and repair of the Complex in coming six years, which will improve operational performance, safety, reliability an efficiency of the plants. It is expected, that these improvements will minimize the pressure on quantity of water resources in the rivers of the Vorotan River Basin as a result of improved compliance with the WUP conditions.

9) Fisheries: As of January 2014, water abstraction for fish farming purposes in the Southern BMA amounted to 18.6 million m^3 according to the WUPs, with major part taking place in the Vorotan River Basin - 173 million m^3. In the Voghji River Basin it amounted to 1.3 million m^3. There is no water use for fish farming in the Meghriget River Basin.

Fisheries in the Southern BMA are small (generally occupying up to 1 ha area), situated in the valleys and **do not have significant pressure on the quality or quantity of water resources.**

10) Agricultural crops and use of fertilizers: As of January 2014, about 7.72% of agricultural lands in the Southern BMA are attributed to arable lands and 0.06% to perennial plantations.

According to the data provided by Department of Agriculture of the Regional administration of Syunik Marz for 2013, about 240 tons of nitrogenous fertilizer were used on applied on 3600 ha arable lands in Vorotan River Basin. It is 4.5 times less than the established norm (according to the norm, cultivation of 1 ha of cropland requires 300 kg of nitrogen fertilizer). About 22 tons of nitrogenous fertilizer were used on 1031 ha arable lands of 10 communities in the Voghji River Basin, which is 14 times less than the established norm. However, according to water quality assessment results in the Voghji River Basin, a poor water quality is observed in the river mouth of the Artsvanik River due to high concentration of nitrite ion. This is a result of return flows from the croplands, due to wrong fertilization practices. In the Meghriget River Basin 49.6 tons of nitrogen fertilizer were used on about 1071 ha arable lands and orchards of 10 communities, which is 6.5 times less than the prescribed norm.

According to expert judgment, crop cultivation and use of fertilizers do not have significant pressure on water quality in the Southern BMA, except lower reaches of the Artsvanik River in the Voghji River Basin.

11) Livestock breeding and overgrazing: Pastures make up more than half (47.7%) of agricultural lands in the Southern BMA. The major branch of agriculture is livestock breeding. As of January 2014, the stock of cows, bulls, horses, etc. made up 54094 heads, and there were about 85606 heads of sheep, goats, pigs, etc. in the Southern BMA.

Livestock breeding is relatively developed in the Vorotan and Voghji River Basins. There are no livestock farms in the Meghriget River Basin.

Surface runoff from the livestock farms discharge into rivers in the Vorotan and Voghji River Basins or infiltrate into groundwater, polluting waters with nitrogen, phosphorus and other organic compounds.

Total volume of waste generated annually in the result of livestock breeding in the Southern BMA is provided in Table 3.18. The annual loads were estimated based number of livestock in the Southern BMA as of January 2014 and normative volumes of manure per animal (ton/year) and concentration of nitrogen and phosphorous.

Table 3.18: Livestock waste in the Southern BMA, as of January 2014

Type	*Number of livestock (thousand heads)*	*Annual discharge norm per 1 head of livestock (ton/year)*			*Total annual discharge (ton/year)*		
		Manure	***Nitrogen$_{tot.}$***	***Phosphorus***	***Manure***	***Nitrogen$_{tot.}$***	***Phosphorus***
Cattle	42.68	8	0.0055	0.0013	341440.0	234.7	55.5
Pig	5.31	2	0.0059	0.0020	10620.0	31.3	10.6
Sheep and Goat	72.26	0.40	0.0107	0.0022	28904.0	773.2	159.0
Chicken	87.04	0.04	0.0130	0.0041	3481.6	1131.5	356.9
Total in the Vorotan River Basin					***384445.6***	***2170.7***	***582.0***
Cattle	10.03	8	0.0055	0.0013	80208.0	55.1	13.0
Pig	3.16	2	0.0059	0.0020	6312.0	18.6	6.3
Sheep and Goat	10.95	0.40	0.0107	0.0022	4381.6	117.2	24.1
Chicken	50.12	0.04	0.0130	0.0041	2004.6	651.5	205.5
Total in the Voghji river basin					***92 906.2***	***842.4***	***248.9***
Cattle	1.392	8	0.0055	0.0013	11136.0	7,7	1,8
Pig	0.456	2	0.0059	0.0020	912.0	2,7	0,9
Sheep and Goat	2.384	0.40	0.0107	0.0022	953.6	25,5	5,2
Chicken	6.26	0.04	0.0130	0.0041	250.4	81,4	25,7
Total in the Meghriget River Basin					***13252.0***	***117.3***	***33.6***
Total in the Southern BMA					***490603.8***	***3130.4***	***864.5***

The data show that the livestock waste quantities are large ***and have significant pressure on the water resources, particularly: in the Gorisget River –from the Brun to Karahunj village, in the Vorotan River – in the Sisian town and downstream to the Shamb Reservoir.***

Overgrazing and associated processes (for example, soil erosion) are observed in a number of areas of the Southern BMA, i.e. on surrounding hills of the Tolors Reservoir. Cattle breeding and overgrazing result in reduction or elimination of vegetation cover. This leads to the loss of soil moisture and increase of erosion under influence of the sun and the wind. This leads to drying of soils and reduction of water permeability and reduction of groundwater resources.

The norms currently applicable in the Republic of Armenia were accepted as basis for assessing the level of overgrazing in the river basin. Pasture area needed for sufficient grazing of large cattle is 0.5 ha/animal on average, while only 0.05 ha pasture area is necessary for a small cattle. The total area covered by pastures in the Southern BMA was 145473 ha in January 2014, while the total number of large cattle was 54094. According to the grazing norms, grazing area per large animal amounts to 2.69 ha (it exceeds the norm about 5 times). Small cattle amounted to 85606, and grazing area per animal constituted 1.7 ha, which is 34 times then required by norm.

Results above indicate that the overgrazing in the Southern BMA is not large-scale and **does not pose significant pressure on the water quality.**

12) Forest logging: As of January 2014, about 28% of the Southern BMA area is covered with forests. According to exert assessment results, forest logging activities (planned and illegal) were implemented on over 630 ha area during the period of 1990-2005. Forest logging became regulated since 2005 resulting in the implementation of sanitary and planned logging. It should be noted that a significant part of forests are in SPANs.

Taking into account the findings of the expert evaluation and the fact that deforestation has a scattered nature forest logging is not considered to exert a significant pressure on the water resources of the river basin.

13) Vehicular transport: As of January 2014, the Yerevan-Yeraskh-Goris-Kapan-Meghri-Iran M-2 highway of international significance and Goris-Stepanakert H-12 highway of republican importance had relatively intensive traffic in the Southern BMA.

Based on results of analysis and assessment of intensity of traffic and freights, as well as taking into account the fact that highway and the roads pass mainly through the areas that are at distance from water resources, it can be concluded the that ***vehicle transport does not have significant pressure on water resources.***

14) Solid wastes: The Kapan, Goris, Sisian, Kajaran, Meghri and Agarak landfills in the Southern BMA are used for disposal of household and other solid wastes (Table 3.19).

The landfill situated 1 km to the east of the Sisian town, in the Uyts village is 30 m away from the Vorotan River, and the landfill for the Goris town, which is 1 km to the south-east of the town, is 600 m away from the Gorisget River. Currently, only 5 ha of the Goris landfill with 10 ha designed capacity are occupied by waste.

The Kapan landfill is situated 5 km to the east of the town, in the Syunik village, in 300 m distance from the Voghji River. The designed capacity of the landfill is 13 ha, and only 4 ha are currently occupied by waste. Solid waste from the Kajaran town is disposed not in the landfill described in Table 3.19, but on the territory of the mine dumps of the Zangezur Copper-Molybdenum Combine, which is covered by soil layer by the company.

Table 3.19: Landfills in the Southern BMA, as of January 2014

Name	***Type***	***Location***	***Designed area, ha***	***Capacity, thousand m^3/year***
Goris	Household, other wastes	Lasti Khut	5	1,1
Sisian	Household, other wastes	Uyts-Aghitu road section	2	0,7
Kapan	Household, other wastes	5 km to the east of the Kapan town, in the Syunik village, border of the Republic of Armenia	13	32,0
Kajaran	Household, other wastes	5 km to the north-east of the Kajaran town	10	14,0
Meghri	Household, other wastes	5-6 km to the west of the town	2,0	5,6
Agarak	Household, other wastes	2.7 km to the north of the town	3,0	5,2

Source: Syunik marz Administration of the Republic of Armenia

The Meghri town landfill rehabilitation program was implemented in the Meghri town within the UN Community development programs in 2007. A new model landfill was constructed, which is fenced, having a drainage system and is regularly covered with a soil layer.

The Agarak Landfill is located 2.7 km away from the town and 1450 m from the Karchevan River.

Except for the Meghri town, landfills in the Southern BMA are in poor condition, sanitary standards are not maintained, there are no fences and disinfection as required.

The municipal landfills in the Southern BMA, despite being in poor condition, **do not pose significant pressure on the water resources.**

The sections of the rivers that pass through the settlements are heavily littered with large quantities of solid wastes, and as of January 2014, these included:

- *The Vorotan River within the Sisian town,*
- *The Sisian River mouth in the area of the Uyts village,*
- *The Gorisget River between the Verishen and Karahunj villages,*
- *The Voghji River within the Kajaran and Kapan towns,*
- *The Vachagan River mouth in the area of Kapan town,*
- *The Meghriget River in the area of Meghri town,*
- *The Karchevan River in the area of the Agarak town and up to the river mouth.*

Solid wastes pose a significant pressure on the water resources of the mentioned sections of the rivers in the Southern BMA.

Assessment of the impact of solid wastes pressure on groundwater resources of the river basins of the Southern BMA was not possible, due to lack of groundwater monitoring data.

Industrial solid waste: In addition to municipal landfills, there are also mining **waste dump sites** in the Southern BMA. The sites in the Voghji Rover Basin belong to two major copper-molybdenum combines – the Kajaran and Kapan. Mining waste dumps of the Zangezur Copper-Molybdenum Combine are located next to the mine, in the adjacent ravine, while waste dump of the Dundee Precious Metals Company are in the Kavart River Basin, in two ravines east of the mine. One of the dumps is near the Kapan town, and the other is in the Achanan village, in the Norashenik River Basin. Waste dumps in the Meghriget River Basin belong to the Sagamar and Agarak Copper-Molybdenum Combines. Industrial waste dumps of the Agarak Copper-Molybdenum Combine are next to the Agarak mine and spreading in the adjacent ravines. Dump sites of Lichkvaz-Tey Gold Polymetallic mine of the Sagamar Company are near the Tkhkut village, right in the floodplain of the Meghriget River.

Large amounts of harmful substances are being washed and transported to water resources in the Southern BMA, particularly during the snowmelt and rainy seasons, spring and summer floods. Surface runoff from the Kajaran waste dump discharges in the Voghji River near the Kajaran town. Surface runoff from the Kapan waste dump also discharges into Voghji River via the Kavart Tributary near the Kapan town. These pollute not only waters of the Voghji River, but also the central part of the Kapan town. Surface runoff from the Hankasar waste dump discharges into the Ajabaj and Geghi Rivers. Surface runoff from the Agarak mine discharges into the Khachidzor (Darazami) and Agarak Rivers, as well as the Karchevan River in the Agarak town and the Meghriget River in the Tkhkut village. This leads to pollution of the rivers with heavy metals and suspended solids.

Taking into consideration all the above mentioned, the mining waste dumps in the Southern BMA pose a significant pressure on the water resources, particularly:

- *The Voghji River, from waste dump of the Zangezur Copper-Molybdenum Combine to the confluence with the Geghi River;*
- *The Voghji River, from confluence point of the Kavart River to the border of the Republic of Armenia;*
- *The Geghi River, from the Ajabaj to the Nor Astghaberd village;*
- *The Norashenik River, from the tunnel of the Combine near the Achanan village to the river mouth;*
- *The Tsakkar River, from the waste dump to confluence with the Voghji River;*
- *The Darapi River, from the waste dump to confluence with the Voghji River;*

- *The Kavart River, from the waste dump to confluence with the Voghji River;*
- *The Karchevan River, from the Agarak town to the Araks River;*
- *The Agarak River from the Khachidzor (Darazami) waste dump to confluence with the Meghriget River.*

Assessment of the impact of mining waste dumps pressure on groundwater resources of the river basins of the Southern BMA was not possible, due to lack of groundwater monitoring data.

15) Tailing dams: There are 6 operational (Artsvanik, Geghanush, Geghi, Darazami, Hovit 1 and Hovit 2) and 4 reclaimed (Voghji, Pkhrut, Darazami and Dastakert) tailing dams in the Southern BMA. The operational tailings are in the Voghji and Meghriget River Basins.

The Artsvanik tailing dam, which was considered to be the largest tailing dam in the world, is in the Artsvanik River Basin. It is operated by the Zangezur Copper-Molybdenum Combine. The tailing dam's design capacity is 310 million m^3, according to the EIA of the Zangezur Copper-Molybdenum Combine. The tailing dam already contained 95 million m^3 of tailing as of January 2014. About 14 million tons of tailings is being discharged into the tailing dam annually, mixed with 40 million m^3 of water.

The Geghanush tailing dam is located in the Geghanush River gorge and operated by the Dundee Precious Metals (former Dino Gold Mining) CJSC. The capacity of was designed to be 8.7 million m^3, according to the old EIA of the design of emergency spillways. However, according to the new EIA report, the design capacity of the dam is 11.33 million m^3. According to actual data, the total capacity of the tailing dam as of 2013 was about 4.6 million m^3, stretching on 32 ha area, with 2.5 million m^3 capacity already used.

The newly established two settling ponds of the Hankasar Combine are on the Ajabaj right tributary to the Geghi River, 2 km south-east the Ajabaj village. These occupy 1.7 ha area.

The Agarak Copper-Molybdenum Combine operates the Darazami, Hovit 1 and Hovit 2 tailings dams, which are filled by about 38.6, 0.9 and 3.5 million m^3, respectively. The Agarak Copper-Molybdenum Combine transports about 10 million m^3 of tailings annually.

Bottom of the operational tailing dams are not lined/insulated, and the surrounding areas are contaminated with tailings. There are land plots and orchards immediately downstream the tailing dams, which are irrigated by filtered waters of the tailing dams rich with heavy metals. Migration trends in the surrounding communities are observed due to hazards of the tailing dams, infertility or loss of lands. In addition, livestock is grazing in the areas surrounding the tailing dams, drinking waters filtered from the dams thus increasing significantly risks human health. Substances accumulated in the tailing dams have adverse impact on the environment.

Reclaimed tailing dams are in the Vorotan and Voghji River Basins. According to data provided by the Urban development department of the Syunik Regional Administration, about 1 million tons of concentrates were stored in the tailing dam of the Dastakert Copper-Molybdenum Combine as of January 2014, which occupies approximately 9.8 hectares. About 2.5 ha of the reclaimed tailing dam area has eroded. Many trenches and cavities, as well as a large well occurred in the eroded parts of the tailing dam, from where the filtered and wash waters discharge into the Kishkosht and Ayriget Rivers heading towards the Tolors Reservoir. The number of trenches and diameter of the well are growing from year to year. The water quality monitoring data for 2011-20121 provided in the EIA report on the Dastakert Mineral Processing Combine of the RA Syunik Marz, prepared by the World of Molybdenum LLC was used for assessing the impact of pressures by the tailing dam on quality of water resources. Water quality class, due to high concentration of heavy metals, reduced in the areas upstream and downstream the tailing dam, while in case molybdenum, the water quality class abruptly dropped to bad (V).

The Voghji, Pkhrut and Darazami reclaimed tailing dams in the Voghji River Basin, that are operated by the Zangezur Copper-Molybdenum Combine˝ CJSC have become eroded and many trenches appeared over time due to precipitations. In addition, many furrows and collapsed areas on the surface of the tailing dam have appeared as a result of pipe installation works implemented in the area.

According to the abovementioned, operational and reclaimed tailing dams in the Southern BMA pose significant pressure on the water quality.

An investment program for processing the industrial waste dumps accumulated and still accumulating in the Voghji, Pkhrut, Artsvanik tailing dams, as well as being generating by activities of the Zangezur Copper-Molybdenum Combine CJSC had been in process of development 2014. It is expected that after implementation of the program the pressure on the water quality of the mentioned operation and reclaimed tailing dams will reduce in the Southern BMA.

3.3.2. Summary of Significant Pressures

The table 3.20 below provides the summary of all significant pressures identified in the rivers of the Southern BMA, including the pressure type, section of the water resource impacted.

Table 3.20: Summary of significant anthropogenic pressures on water quality of the rivers in the Southern BMA

#	*Pressure type*	*Section of water resource*	*Comment*
1	Water abstraction for industrial purposes	The Voghji River, from the Zangezur Copper-Molybdenum Combine of the Kajaran town to the Voghji tailing dam	Water abstraction from the Voghji River for industrial purposes poses a significant pressure on quantity of water resources in terms of not maintaining the ecological flow in the section between the Kajaran town and Voghji tailing dam
2	Water abstraction for irrigation purposes	The Sisian River, from the Tasik village to the Tolors Reservoir; The Gorisget River, from the Brun village to the border of the RA	The ecological flow is not maintained in the Sisian and Gorisget Rivers in the result of excessive water use for irrigation during the summer-autumn period
3	Disposal of communal wastewater, including wastewater pits	The Vorotan River, from the Sisian town to the Shamb Reservoir; The Sisian River, from Tolors Reservoir to the river mouth; The Gorisget River, from the Goris town to the border of the RA; The Voghji River, from the Kajaran town to the Voghji tailing dam; The Voghji River, from the Kapan town to the border of the RA; The Vachagan River, from the Kapan town to the river mouth; The Karchevan River, from the Agarak town to the river mouth	Communal wastewater poses significant pressure on quality of water in the rivers in the Southern BMA rivers. Communal wastewater of the Sisian, Goris, Kajaran, Kapan and Agarak towns poses pressure on quality of waters in the Vorotan, Gorisget, Voghji, Vachagan and Karchevan Rivers.
4	Mining: wastewater discharge and mines	The Voghji River, from the Zangezur Copper-Molybdenum Combine to confluence with the Geghi River; The Voghji River, from confluence with the Kavart River in the Kapan town to the border of the RA; The Geghi River, from the Ajabaj to Nor Astghaberd village; The Norashenik River, from pipeline of the Artsvanik tailing dam to the river mouth; The Artsvanik River, from the tailing dam to the river mouth; The Geghanush River, from tailing dam to the river mouth; The Kavart River, from the mine to the river	Industrial wastewaters of the Zangezur Copper-Molybdenum Combine, Agarak Copper-Molybdenum Combine, Dundee Precious Metals Ler-Ex Copper-Molybdenum Combines operated in the Southern BMA pose significant pressure on the water quality of water resources in the rivers. Surface runoffs rich with heavy metals that are formed in the territory of the Kajaran, Kapan, Hankasar, Agarak, Lichkavaz- Tey, Aygedzor, Terterasar, Lichk mines discharge into the surrounding rivers and pollute the them thus posing significant pressure on water quality.

#	Pressure type	Section of water resource	Comment
		mouth, The Tsakkar River, from confluence of the Makanajur tributary to the river mouth; The Darapi River entirely, The Karchevan river, form the Agarak Copper-Molybdenum combine to the river mouth; The Meghriget River, from the Tkhkut to Vardanidzor village; The Khachidzor River, in the area of the Agarak mine Agarak river in the area of Agarak deposit	
5	HPPs	The Vorotan River, form the Angeghakot reservoir to Tatev HPP; The Sisian River, form the Tolors Reservoir to the river mouth; The Tsghuk Wiver, from the water abstraction point of the SHHP on about 2550 m elevation to the river mouth; The Shaqi river, from the Shaqi SHPP to the river mouth; The Voghji River, from the Geghi River to the confluence up to the Kapan town; The Meghriget River from the Lichk village to confluence with the Gozgoz tributary on 1700-1460 m elevation; The Meghriget River from the Vardanidzor village to the Meghri town on about 1000-700 m elevation	Ecological flow of the Vorotan, Sisian, Tsghuk, Voghji and Meghriget rivers of Southern BMA is not maintained due to water abstraction by HPPs
6	Livestock breeding and overgrazing	The Gorisget River from the Brun village to Karahunj village; The Vorotan River within the Sisian town; The Vorotan River from the Sisian town to the Shamb Reservoir	Livestock breeding is relatively well developed in the Vorotan River Basin. Surface runoff, wash waters from the livestock farms in the Vorotan River Basin discharge into the rivers and pollute waters with nitrogen, phosphorus and other organic compounds. Analysis of data on number of cattle heads and cattle distribution shows that livestock breeding poses a significant pressure in some areas within the Vorotan River Basin.
7	Solid waste	The Vorotan River, in the area of the Sisian town; The Sisian River, in the area of the Uyts village; The Gorisget River, between the Verishen and Karahunj villages; The Voghji River, at the border of the Kajaran and Kapan towns; The Vachagan River, from the Kapan town to the river mouth; The Voghji River, from the Kajaran town to confluence with the Geghi River; The Voghji River, from the confluence with the Kavart River to the border of the RA; The Geghi River, from the Ajabaj to Nor Astghaberd village;, The Kavart River, from the mine to the river mouth;	Due to improper solid waste disposal, riverbeds of the described sections of the rivers in the Southern BMA are heavily polluted with large quantities of solid wastes. This poses a significant pressure on water quality. Mining waste dumps of the Kajaran, Kapan, Agarak and Lichkvaz-Tey mines pose a significant pressure on the water quality in the rivers of the Southern BMA.

#	Pressure type	Section of water resource	Comment
		The Norashenik River, from the pipeline of Artsvanik tailing dam to the river mouth; The Tsakkar River, from confluence of the Makanajur tributary to the river mouth; The Darap River entirely; The Meghriget River from the Tkhkut to Vardanidzor village; The Meghriget River within the Meghri town; The Karchevan River from the Agarak Copper-Molybdenum Combine to the river mouth; The Khachidzor (Darazami) River from the waste dumps of the Agarak Combine to the Darazami tailing dam; The Agarak River, in the Agarak Copper-Molybdenum Combine area.	
8	Tailings	Ayriget tributary Kishkosht river from Dastakert mine to the river mouth Ayriget river from confluence with Kishkosht to Torunik village Voghji river from Zangezur copper-molybdenum combine to confluence with Geghi river Voghji river from Kapan town to the border of the Republic of Armenia Geghi river from Ajabaj to Nor Astghaberd settlement Norashenik river from Artsvanik tailing pipe to the river mouth , Artsvanik river from tailing to the river mouth , Geghanush river from tailing to the river mouth , Karchevan river from Agarak town to the river mouth, Khachidzor (Darazami) river from Darazami tailing	The Dastakert open non-operational copper-molybdenum mine and the tailing areas in the Vorotan River Basin pose a significant pressure on water quality in the Kishkosht and Ayriget Rivers. The Voghji, Pkhrut and Darazami reclaimed tailing dams in the Voghji River Basin have become eroded over time due to pre precipitation. In addition, many furrows and collapsed areas on the surface of the tailing dams have appeared as a result of pipe installation works implemented in the area. These pose significant pressures on the water quality of water resources. A significant pressure is posed on the water quality due to non-insulated bottoms of the Artsvanik, Geghanush and Geghi tailing dams in the Voghji River Basin of Southern BMA, as well as the Darazami, Hovit 1 and Hovit 2 tailing dams in the Meghri River Basin.

The results of pressures and impacts analysis serve a basis for delineation of water bodies and determination of water bodies at risk in the Southern BMA (Chapter 4).

3.4. Assessment of Impacts on Water Resources and Aquatic Ecosystems in Possible Emergency Situations

Phenomena causing possible emergency situations that may have detrimental effect on water and aquatic environment are erosion, floods, mudflows, water logging, dams and embankments failure, raising of groundwater horizons, swamping and salination of soils, formation of new ravines, deepening of the river beds, activation of landslides, water scarcity, droughts and other dangerous meteorological phenomena.

Phenomena (erosion, floods, mudflows, water logging, destruction of dams and river banks) causing emergencies that may have detrimental effect on water and aquatic environment in the Southern BMA are characterized in sections 1.2.6 and 2.6 of this management plan.

CHAPTER 4: CLASSIFICATION OF WATER BODIES, ACCORDING to MANAGEMENT CHARACTERISTICS OF WATER RESOURCES OF THE RIVER BASIN

4.1. Delineation of Surface Water Bodies

4.1.1. Criteria and Procedure for Delineation

According to the EU WFD, a Surface Water Body means a discrete and significant element of surface water such as a lake, a reservoir, a stream, river or canal, part of a stream, river or canal, transitional water or a stretch of coastal water which differ from each other by specific natural characteristics, the nature of human pressure and other essential parameters.

The main objectives of water body delineation include:

1. Elaboration of necessary measures for improving the water status (only for water bodies at risk),
2. Elaboration of a WFD compliant monitoring program.

Surface water identification and delineation can be applied for rivers (tributaries) having 10 km^2 and bigger catchment areas, as well as for lakes (reservoirs) having 0.5 km^2 and bigger catchment. Smaller water bodies, as well as temporary (seasonal) flows are not subject to delineation.

The surface water bodies within a basin belong to one of two classes of surface water bodies, namely to “rivers” or “lakes” category. In addition to these classes, water bodies at risk, artificial and heavily modified water bodies are also identified.

According to the definition of WFD, Water Body at Risk (WBR) is a water body that is identified as being at risk of failing the environmental quality objectives based on the basin characterization, pressure-impact analysis and/or operational monitoring results.

Heavily Modified Water Body (HMWB) means a body of water which, as a result of physical alterations by human activity, is substantially changed in character.

Artificial water body (AWB) means modification of river beds and reservoirs and artificial and artificial ponds.

The rest of the Southern BMA natural surface water bodies are characterized as not being at risk, according to the following standards of the EU WFD CIS Guidance Document No 2(Identification of Water Bodies):

- Small rivers and tributaries of surface water can be identified as part a of the body surface water category of the same type or main rivers, as a single body of water;
- Small rivers: (a) belonging to the same type, (b) influenced by the same pressure category and level and (c) having an influence on another well delimited water body, may be grouped into one water body.

In addition, in certain cases, also the following factors were taken into consideration:

- Hydro-morphological characteristics;
- Hydrological characteristics;
- The fact of being a confluence of rivers, being located adjacent to water bodies at risk or artificial water bodies, or being located between artificial water bodies or water bodies at risk,
- Having a status of protected area;
- Being located adjacent to state border.

4.1.2. *Identification of Water Bodies at Risk*

The identification of water bodies at risk (WBR) is based on significant environmental pressures on quantity and quality of water resources specified in the previous chapter. The following **30 water bodies at risk** have been identified in Southern BMA in the result of this assessment, including 10 in the Vorotan River Basin, 13 in the Voghji River Basin and 7 in the Meghriget River Basin (Figure 4.1).

WBR-01. *The Vorotan River, in the Sisian town:* This water body is delineated based on qualitative parameters. Pressures of the household waste and communal wastewater, also return flows from agriculture, including livestock breeding are present in this section of the Vorotan River within the Sisian town. The total length of the WBR is 3.9 km.

WBR-02. *The Vorotan River, downstream the Sisian town up to the Shamb Reservoir:* This water body is delineated due to pressures of the household waste and communal wastewater from the Sisian town, agricultural return flows, including from livestock breeding, as well as failure to maintain the ecological flow. The total length of the WBR is 13.6 km.

WBR-03. *The Vorotan River from the Shamb Reservoir to the border of the RA:* This water body is delineated because ecological flow is not maintained in this section as a result of water abstraction by the Tatev HPP. The total length of the WBR is 33.9 km.

WBR-04. *The Tsghuk River form the Spandaryan Canal to Spandaryan Reservoir:* This water body is delineated because ecological flow is not maintained in this section as a result of water abstraction for hydropower generation and irrigation purposes. The total length of the WBR is 4.2 km.

WBR-05. *The Shaqi River, downstream the Shaqi village (Shaqi Waterfall) and to the river mouth:* This water body is delineated because ecological flow is not maintained as a result of operation the Shaqi SHPP. The total length of the WBR is 1.7km

WBR-06. *The Sisian River, from the Tasik village to the Tolors Reservoir*: This water body is delineated because ecological flow of the Sisian River is not maintained as a result of water abstraction for irrigation purposes. The total length of the WBR is 3km.

WBR-07. *The Sisian River, from the Tolors Reservoir to the river mouth:* This water body is delineated because ecological flow is not maintained as a result of not regulating water flow from the Tolors Reservoir. The total length of the WBR is 4.4km.

WBR-08. *The Ayriget River, from the confluence point of the Kishkosht tributary to Torunik village and the Kishkosht tributary, from the Dastakert mine to the river mouth:* This water body is delineated because of the pressure of the Dastakert Copper-Molybdenum mine, runoff from the tailing dam. The total length of the WBR is 7.3km.

WBR-09. *The Gorisget River form the Brun village to the end of the Goris town:* This water body is delineated due to pressures from the household waste and communal wastewaters of the Brun, Verishen villages and the Goris town, agricultural return flows, as well as not maintenance of the ecological flow as a result of water abstraction for irrigation purposes. The total length of the WBR is 5.3 km.

WBR-10. *The Gorisget River form the Goris town to the border of the RA:* This water body is delineated because of pressure of household wastewaters of the Goris town, as well as agricultural return flows. The total length of the WBR is 11.9 km.

WBR-11: *The Voghji River from the confluence of the Ughtapan River to the Zangezur Copper-Molybdenum Combine of the Kajaran town*: This water body is delineated based on quantitative parameters. Ecological flow in this section of Voghji River is not maintained due to water abstraction for industrial purposes. The total length of the WBR is 2.5 km.

WBR-12: *The Voghji River from the Zangezur Copper-Molybdenum Combine to the Voghji reclaimed tailing dam*: This water body is delineated based on qualitative indicators. Significant pressures on this section of Voghji River include: leakages from wastewater disposal system of Zangezur Copper-Molybdenum Combine; surface runoff formed in the Zangezur mine area; communal-household and solid wastes of the Kajaran town, as well as occurrence of a heavily modified water body (the Voghji reclaimed tailing dam). The total length of the WBR is 7.6 km.

WBR-13: *The Voghji River from the Voghji reclaimed dam tailing to the Geghi River confluence:* This water body is delineated due to pressure of surface runoff from the mine, waste dumps of the Kajaran Copper-Molybdenum Combine and wash waters of the Voghji tailing dam. The total length of the WBR is 3.9 km.

WBR-14: *The Voghji River from confluence with Geghi River to Kapan town:* This water body is delineated based on quantitative indicators. The ecological flow of the Voghji River is not maintained in this section due to water abstraction for hydropower generation. The total length of the WBR is 5.4 km.

WBR-15: *The Voghji River in the Kapan town from the beginning of the town to confluence section with Kavart tributary:* The water body is delineated based on pressure of the Kapan town household waste and communal wastewater. The total length of the WBR is 10 km.

WBR-16: *The Voghji River from confluence with Kavart tributary to the border of the Republic of Armenia*: This water body is delineated based on pressure of the Kapan town household waste and communal- wastewater, surface runoff formed in the result of mine operation and waste dumps in the mine area of Kapan Copper-Molybdenum Combine, as well as runoff from the Geghanush and Artsvanik tailings dams. The total length of the WBR is 25.6 km.

WBR-17: *The Tsakkar River from confluence with Makanajur to the river mouth:* The water body is delineated based on qualitative indicators. Significant pressures on the quality of water resources in this section include surface runoff rich with mineral elements formed in the Zangezur mine area. The total length of the WBR is 3.6 km.

WBR-18: *The Darapi River with its tributaries up to Darazami tailing dam*: This water body is delineated based on qualitative indicators. Significant pressures on this section include surface runoff rich with mineral elements generated in waste dump site as well as mine area of the Zangezur Copper-Molybdenum Combine. The total length of the WBR is 4.2 km.

WBR-19: *The Right-bank tributary of the Geghi River, from the waste dumps of the Ler-Ex Copper-Molybdenum Combine to the river mouth, and the Geghi River from the confluence of the tributary to the Nor Astghaberd village:* This water body is delineated based on qualitative indicators. Significant pressures at this section of the Geghi River include leakages from the drainage system of the Ler-Ex Copper-Molybdenum Combine and surface runoff formed in the Hankasar mine area. The total length of the WBR is 3.2 km.

WBR-20: *The Kavart River from the mine area of the Kapan Copper-Molybdenum Combine to the river mouth*: This water body is delineated based on qualitative indicators. Significant pressures of this section include surface runoff rich with mineral elements formed in the result of mine exploitation and waste dumps at the mine area of the Kapan Copper-Molybdenum Combine, as well as the household waste and communal wastewater of the Kapan town. The total length of the WBR is 3.2 km.

WBR-21 *The Vachagan River within the Kapan town:* This water body is delineated based on pressure of Kapan town waste and communal wastewater. The total length of the WBR is 1.7 km.

WBR-22: *The Geghanush River from the Geghanush tailing dam to the river mouth*: This water body is delineated due to runoff from the Geghanush tailing dam. The total length of the WBR is 0.8 km.

WBR-23: *The Norashenik River from wastewater pipeline of the Artsvanik tailing dam to the river mouth:* This water body is delineated mainly due to surface runoff formed by precipitation in the mine area of the Dundee Precious Metals Copper-Molybdenum combine, as well as leakages from drainage water pipe connecting to the Artsvanik tailing dam. The total length of the WBR is 5.6 km.

WBR-24. *The Meghriget River, from the Lichk village to the confluence of the Gozgoz tributary:* This water body is delineated mainly due failure to maintain ecological flow in the Meghriget River at the elevation mark of 1700-1460m as a result of SHHP operation. The total length of the WBR is 4.6 km.

WBR-25. *The Meghriget River, between the Tkhkut and Vardanidzor communties:* This water body is delineated due to pressure of surface runoff and return flows from the waste dumps in the area of the Lichkvaz-Tey, Aygedzor and Terterasar mines. The total length of the WBR is 2.6 km.

WBR-26. *The Meghriget River, from the Vardanidzor village to the Meghri town:* This water body is delineated mainly due to failure to maintain ecological flow in the middle stream of the Meghriget River at the elevation mark of 1000-700m as a result of operation of the SHPP. The total length of the WBR is 8.1 km.

WBR-27. *The Meghriget River, in the area of the Meghri town*: This water body is delineated mainly due to pollution with solid waste of the Meghri town, as well as failure to maintain ecological flow in Meghriget. The total length of the WBR is 3.1 km.

WBR-28. *The Karchevan River, from the Karchevan village to the Agarak Copper-Molybdenum Combine:* This water body is delineated mainly due to water abstraction from upstream section of the

Karchevan River (up to the Agarak Copper-Molybdenum Combine) by the local population and failure to maintain ecological flow. The total length of the WBR is 1.7 km.

WBR-29. *The Karchevan River, from the Agarak Copper-Molybdenum Combine to the river mouth:* This water body is delineated mainly due to pressure of household wastewater. The total length of the WBR is 4.8 km.

WBR-30. *The Khachidzor River, from the Agarak Copper-Molybdenum Combine waste dump to Darazami tailing dam:* This water body is delineated mainly due to pressures of runoff and return flows from the waste dumps. The total length of the WBR is 3 km.

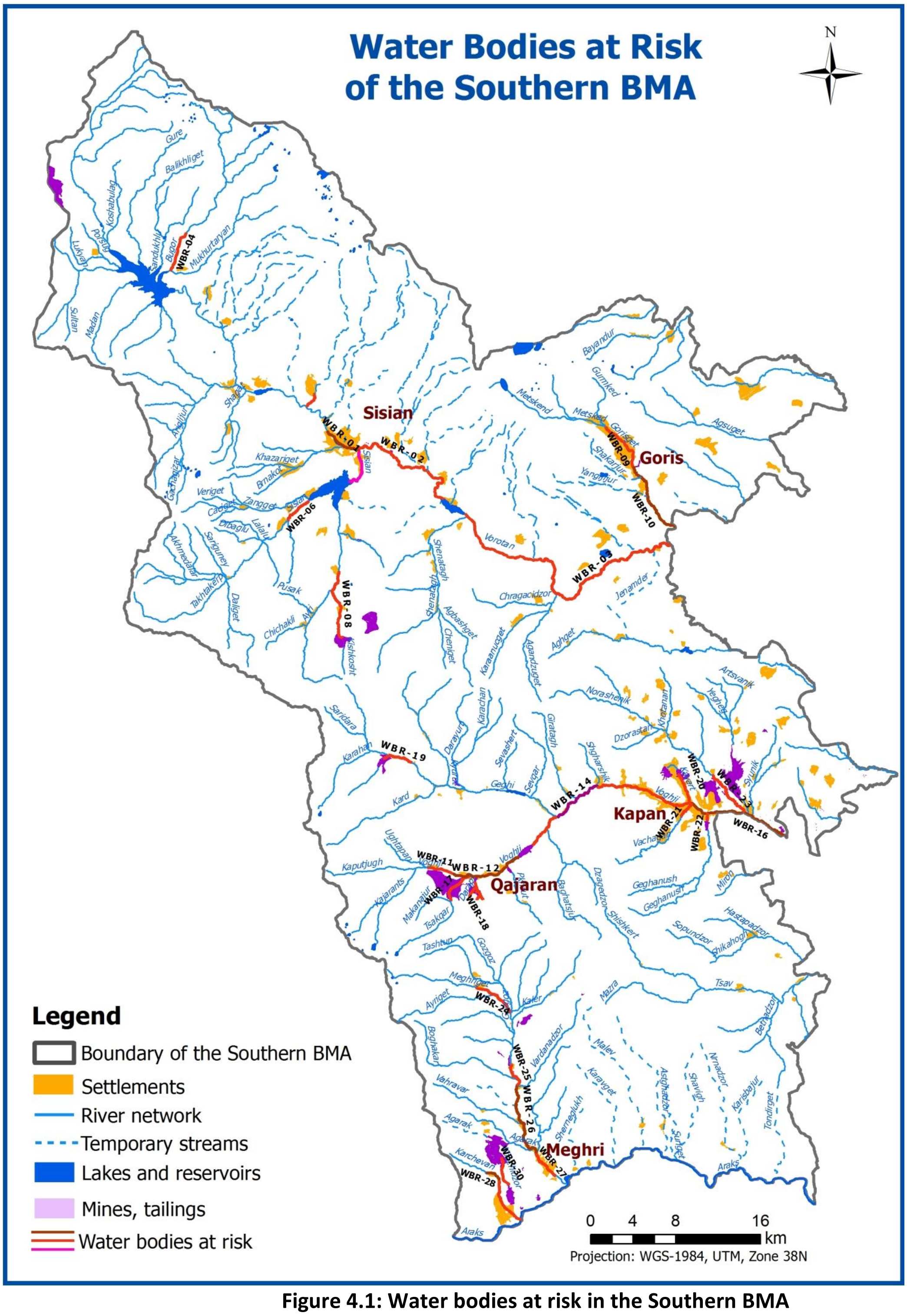


Figure 4.1: Water bodies at risk in the Southern BMA
Source: USAID Clean Energy and Water Program, 2015

4.1.3. Identification of Artificial Water Bodies

Eleven artificial water bodies have been delineated in Southern BMA, including 9 in the Vorotan River Basin and one in the Voghji and one in the Meghriget River Basins (Figure 4.2).

AWB-01: *The Vorotan-Arpa-Sevan tunnel*: The tunnel was not operated in 2014. However, if necessary, about 165 million $m^{3\ of}$ water will be annually directed via the Spandaryan tunnel to the Kechut Reservoir and to the Lake Sevan. The length of the tunnel within the Vorotan River Basin is 6.5 km.

AWB-02. *The Spandaryan canal:* it abstracts water from the Tkhkut and Mokhraget rivers at 2350 m elevation. The total length of the canal is 43 km and carrying capacity is 2.5 m ^{3}/sec. Canal water is used for the irrigation of about 1,400 hectare lands.

AWB-03. *The Derivation canal of Spandaryan HPP* abstracts the water from Spandaryan Reservoir with a discharge rate of 30 m^3/s and directs it to Spandaryan HPP. The total length of the canal is 9.2 km.

AWB-04. *The Derivation canal for diverting water from Angeghakot reservoir to Tolors reservoir*: The canal abstracts water from the Angeghakot Reservoir with rate of 23 m^3/s and diverts it to the Tolors Reservoir. The total length of the canal is 11 km.

AWB-05. *The Derivation canal of Shamb HPP* abstracts the water from the Tolors Reservoir with discharge rate of 75 m^3/s and diverts it to the Shamb HPP. The total length of the canal is 8.9 km.

AWB-06. *The Derivation canal of Tatev HPP* abstracts the water from the Shamb Reservoir with discharge rate of up to 25 m^3/s and directs it to Tatev HPP's regulation Reservoir. The total length of the canal is 13.6 km.

AWB-07. *The Metsashen canal* abstracts water from Metsashen River and directs it to Karahunj Reservoir. The total length of the canal is 10.4 km.

AWB-08. *The Karahunj reservoir's canal* abstracts water from Karahunj Reservoir. The total length of the canal is 7.9 km and carrying capacity is 0,2 m^3/s. Canal water is used for the irrigation of about 246 hectare lands.

AWB-09. *The Vorotan main canal* abstracts water from Tatev HPP's daily regulation reservoir. The total length of the canal is 29.1 km and carrying capacity is 1.2 m^3/s. Canal water is used for the irrigation of about 705 hectare lands.

AWB-10. *The flow diversion tunnel of the Artsvanik River*, which starts from tailing discharge section of Artsvanik River and ends downstream the Achanan village, at the discharge section of the Achanan River. The length of the tunnel is 3.6 km.

AWB-11. *The Karchevan canal* abstracts water from the Boghakar tributary to the Meghriget River, from elevation of about 1750m. The canal diverts water from the Meghriget to the Karchevan River basin. The total length of the canal is 10 km and carrying capacity is 0.5 m3/s. Canal water is used for the irrigation of about 200 hectare lands.

4.1.4. Heavily Modified Water Bodies

Fourteen heavily modified water bodies have been delineated in Southern BMA, including 6 in the Vorotan River Basin, 7 in the Voghji River Basin and 1 in the Meghriget River Basin (Figure 4.2).

HMWB-01. *The Spandaryan Reservoir* is located on the Vorotan River. The total storage capacity of the reservoir is 257 million m^3, useful capacity is 218 million m^3, while the water table surface area during normal level is 1025 ha. Reservoir waters are used for hydropower generation, irrigation, fish production and nature protection purposes.

HMWB-02. *The Angeghakot Reservoir* is located *on the* Vorotan River. The total storage capacity of the reservoir is 3.4 million m^3, useful capacity is 2.9 million m^3, while the water table surface area during normal level is 54ha. Reservoir waters are used for hydropower generation and fish production purposes.

HMWB-03. *The Shamb Reservoir* is located *on* the Vorotan River. The total storage capacity of the reservoir is 13,6 million m^3, useful capacity is 11.8 million m^3, while the water table surface area during normal level is 11ha. Reservoir waters are used for hydropower generation and fish production purposes.

HMWB-04. *The Tolors Reservoir* is located *on* the Sisian River. The total storage capacity of the reservoir is 96 million m^3, useful capacity is 80 million m^3, while the water table surface area during normal level is 480 ha. Reservoir waters are used for hydropower generation, irrigation, fish production and nature protection purposes.

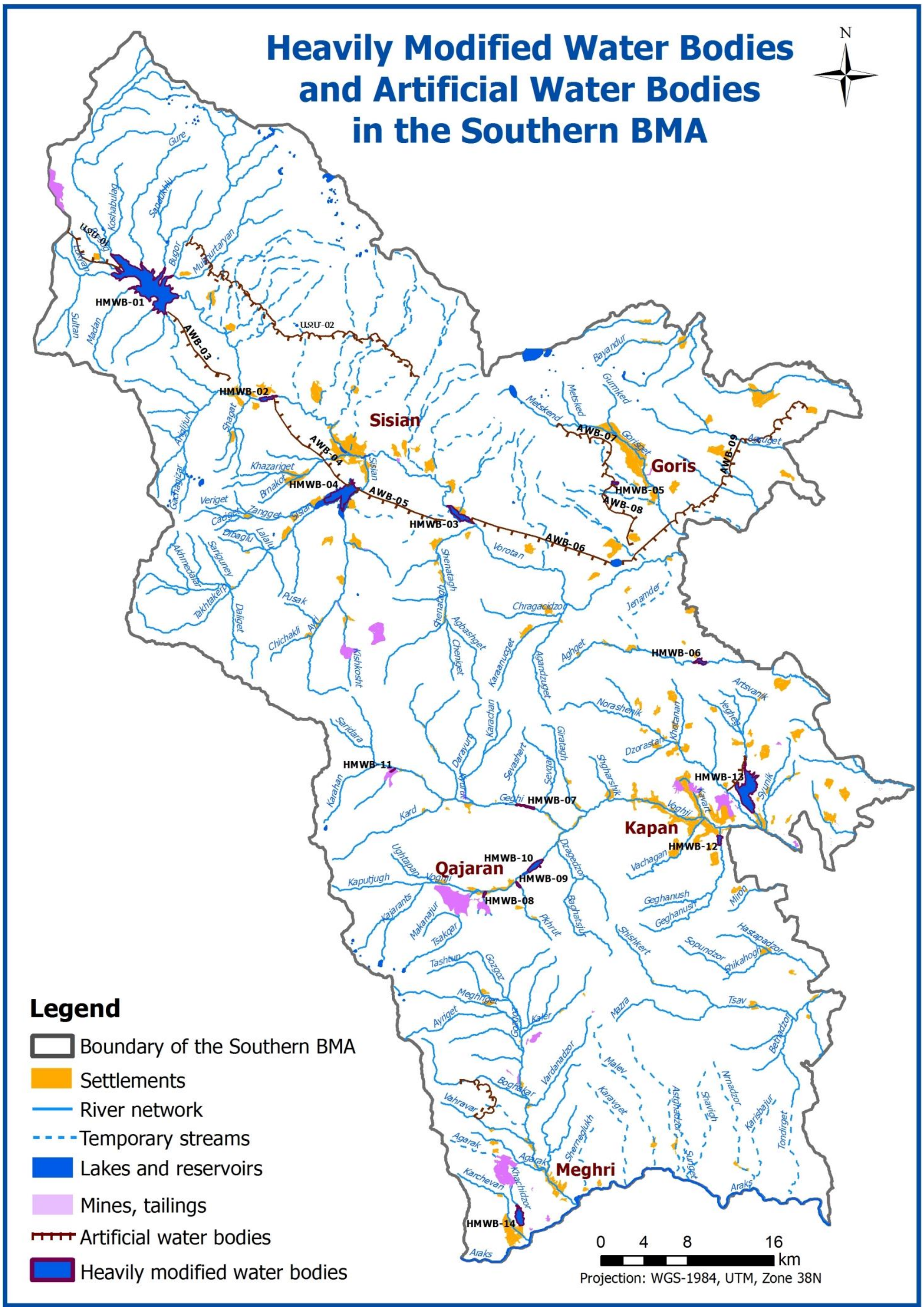


Figure 4.1: Artificial and heavily modified water bodies in the Southern BMA

Source: USAID Clean Energy and Water Program, 2015

HMWB-05. *The Karahunj Reservoir* is located on the Shakarajur River. The total storage capacity of the reservoir is 1,27 million m^3, useful capacity is 1 million m^3, while the water table surface area is during normal level is 18,3 ha. Reservoir waters are used for irrigation purposes.

HMWB-06. *The David-Bek Reservoir* is located on the Qashun River. The total storage capacity of the reservoir is 2,5 million m^3, useful capacity is 2,1 million m^3, while the water table surface area is during normal level is 40 ha. Reservoir waters are used for irrigation and hydropower generation purposes.

HMWB-07: *The Geghi Reservoir* is located on the Geghi River. The total storage capacity of the reservoir is 15 million m^3, usable storage is 12 million m^3, while the water table surface area during normal level covers 35 ha. Reservoir waters are used for hydropower generation, fish production and environmental purposes.

HMWB-08: *The Pkhrut reclaimed tailing dam* is located at the lower reaches of the right-bank tributary to the Voghji River- Pkhrut River. In the past, the tailing was operated by the Zangezur Copper-Molybdenum Combine, while now it is reclaimed. Storage capacity of the tailing is about 3.2 million m^3, which is fully used. Tailing dam covers 11.2 ha area.

HMWB-09: *The Darazami reclaimed tailing dam* is located at the lower reaches of right-bank tributary to the Voghji River- Darapi River. In the past, the tailing was operated by the Zangezur Copper-Molybdenum Combine, while now it is reclaimed and covered with waste dumps. Storage volume of the tailing is about 3 million m^3, which is fully used. Tailing dams covers 0.9 ha area.

HMWB-10: *The Voghji reclaimed tailing dam* is located on the Voghji River, downstream the Kajaran town. In the past, the tailing was operated by the Zangezur Copper-Molybdenum Combine, while now it is reclaimed. Storage capacity of the tailing is about 25 million m^3, which is fully used. Tailing covers 53 ha area.

HMWB-11: *The settling ponds of the Ler-Ex Copper-Molybdenum Combine* are located on the right-bank tributary to the Voghji River. These are operated by the Ler-Ex company. The area of two settling ponds is 1.7 ha area.

HMWB-12: *The Geghanush tailing dam* is located at the lower reaches of the Geghanush River. It is operated by the Kapan Copper-Molybdenum Combine. The total storage capacity of the tailing is 15.9 million m^3, of which 4.65 million m^3 is used. The tailing covers 12.8 ha area.

HMWB-13: *The Artsvanik tailing dam* is located on the Artsvanik River. It is operated by the Zangezur Copper-Molybdenum Combine. The total storage capacity of the tailing is 310 million m^3, of which 118 million m^3 is used. Currently surface of the tailing is 399ha. The tailing disposed in the tailing dam amount to 14 million m^3 annually.

HMWB-14. *The Darazami tailing dam* is located on the Darazami River. The total storage capacity of the tailing dam is 38.6 million m^3, while the surface area is about 94 ha. 10 million m^3 of tailings of the Agarak Copper-Molybdenum Combine are discharge into the tailing dam annually.

4.1.5. Delineation of Surface Water Resources of the Southern BMA into Separate Water Bodies

After delineating of water bodies at risk, artificial and heavily modified water bodies, about 55 other water bodies (WB) have been delineated in the Southern BMA, including 23 other water bodies in the Vorotan River basin, 19 - in the Voghji River Basin and 13 - in the Meghriget River Basin (Figure 4.4).

WB-01. *The Vorotan River up to the Spandaryan Reservoir:* This water body is delineated taking into consideration the hydromorphological and hydrological characteristics. The total length is 73 km.

WB-02. *Small rivers discharging into the Spandaryan Reservoir:* This water body is delineated, taking into consideration the hydromorphological and hydrological characteristics. The total water body length is 101.9 km.

WB-03. *TheTsghuk and Mokhraget Rivers, up to the Spandaryan Canal:* This water body is delineated, taking into consideration the canal itself that initiates from Tsghuk River and ends on Mokhraget. The total water body length is 54.6 km.

WB-04. *The Mokhraget River from the Spandaryan canal to Spandaryan Reservoir:* This water body is delineated, taking into consideration the presence of the reservoir and the canal. The total water body length is 4.4 km.

WB-05. *The Aragiljur River, up to confluence with the Vorotan River:* This water body is delineated, taking into consideration that it is the main confluence of river flow, as well as considering the hydromorphological and hydrological characteristics. The total water body length is 50.8 km.

WB-06. *The Shagar River to confluence with the Vorotan River*: This water body is delineated, taking into consideration that it is the main confluence of river flow, as well as considering the hydromorphological and hydrological characteristics. The total water body length is 19.6 km.

WB-07. *The Vorotan River, from the Spandaryan Reservoir to Angeghakot Reservoir:* This water body is delineated, taking into consideration the presence of the two AWBs of Spandaryan and Angeghakot reservoir. The total water body length is 17.4 km.

WB-08. *The Vorotan River, from the Angeghakot Reservoir to confluence with the Shaqi River:* This water body is delineated, taking into consideration the presence of AWB and WBR. The total water body length is 4.2 km.

WB-09. *The Vorotan River, from confluence point with the Shaqi Riverin the Sisian town:* This water body is delineated, taking into consideration the presence of WBR. The total water body length is 4.5 km.

WB-10 *The Brnakot River with its tributaries:* This water body is delineated, taking into consideration that it is the main confluence of river flow, as well as hydromorphological and hydrological characteristics. The total water body length is 28.6 km.

WB-11. *The Sisian River, from its headwaters to the Tasik villages with its tributaries:* This water body is delineated taking into consideration river water quality, as well as considering the hydromorphological and hydrological characteristics, as well as the presence of WBR. The total water body length is 94.8 km.

WB-12. *The* Zaget River with its tributaries*:* This water body is delineated taking into consideration hydromorphological and hydrological characteristics of river water quality. The total water body length is 24.8 km.

WB-13. *The Ayriget headwaters to confluence with the Kishkosht River:* This water body is delineated taking into consideration hydromorphological and hydrological characteristics of river water quality. The total water body length is 23.8 km.

WB-14. *The Kishkosht River up to the Dastakert mine:* This water body is delineated because of its good water quality, as well as the presence of WBR. The total water body length is 3.6 km.

WB-15. *The Ayriget River, from Torunik village to the Tolors Reservoir:* This water body is delineated taking into consideration the presence of AWB and WBR. The total length is 13.9 km.

WB-16. *The Loradzor River and its tributaries:* This water body is delineated taking into consideration that it is the main confluence of river flow, as well as considering the hydromorphological and hydrological characteristics. The total water body length is 48 km.

WB-17. *The Tatev River with its tributaries:* This water body is delineated taking into consideration that it is the main confluence of river flow, as well as considering the hydromorphological and hydrological characteristics. The total water body length is 31.2 km.

WB-18. *The Gorisget River up to the Brun village:* This water body is delineated because of its good water quality, as well as the presence of WBR. The total water body length is 24.9 km.

WB-19. *Tributaries of the Hagari River in the area of the RA:* This water body is delineated taking into consideration hydromorphological and hydrological characteristics and the presence of AWB. The water body includes small tributaries of Hagari River to the north-east of Gorisget up to the border of the Republic of Armenia. The total water body length is 93.3 km.

WB-20. *The Qashun Rriver, from its headwaters to the David-Bek Reservoir:* This water body is delineated taking into consideration hydromorphological and hydrological characteristics and the presence of AWB. The water body includes small tributaries of Hagari River to the north-east of Gorisget up to the border of the Republic of Armenia. The total water body length is 16.1 km.

WB-21. *The Qashun river, from the David-Bek Reservoir to the border of the RA:* This water body is delineated taking into consideration hydromorphological and hydrological characteristics and the presence of AWB. The total water body length is 24.5 km.

WB-22. *Small tributaries of the Vorotan River south-east of the Qashun River basin:* This water body is delineated taking into consideration hydromorphological and hydrological characteristics. The total water body length is 33.2 km.

WB-23. *The Sev Lich lake:* This water body is delineated taking into consideration hydromorphological and hydrological characteristics and the existence of the sanctuary. The total surface of the water body is 185 ha.

WB-24. *The Voghji River, up to confluence with the Ughtapan tributary, together with Kaputjugh, Kajaran and Ughtapan:* This water body is delineated taking into consideration hydromorphological and hydrological characteristics and the presence of WBR. The total water body length is 30 km.

WB-25. *The Tsakkar River, with its Makanajur tributary, from the headwaters to the Zangezur Copper-Molybdenum mine:* This water body is delineated taking into consideration hydromorphological and hydrological characteristics and the presence of WBR. The total water body length is 12.6 km.

WB-26. *The Pkhrut River:* This water body is delineated taking into consideration hydromorphological and hydrological characteristics and the presence of WBR. The total water body length is 6.9 km.

WB-27. *The Dzagedzor River and its tributary:* This water body is delineated as the main confluence section of the river flow taking into consideration hydromorphological and hydrological characteristics and the presence of WBR. The total water body length is about 22 km.

WB-28. *The Geghi River, from the headwaters (Karahan and Ajabaj tributaries) to the Ajabaj settlement:* This water body is delineated taking into consideration hydromorphological and hydrological characteristics and the presence of WBR. The total water body length is 23.2 km.

WB-29. *Right-bank tributary of the Geghi River, from headwaters to Copper-Molybdenum Combine settling ponds of the Ler-Ex LLC:* This water body is delineated taking into consideration the presence of WBR. The total water body length is 5.2 km.

WB-30. *The Geghi River, from the Nor Astghaberd village to the Geghi Reservoir (Kyurut, Karachan and Sevashert tributaries):* This water body is delineated taking into consideration hydromorphological and hydrological characteristics, as well as the presence of AWB and WBR (Geghi reservoir). The total water body length is 61.5 km.

WB-31. *The Kard River:* This water body is delineated as the main confluence section of the river flow taking into consideration hydromorphological and hydrological characteristics. The total water body length is 13.5 km.

WB-32. *The Geghi River, from the Geghi Reservoir to the confluence of the Voghji River with Sevkar tributary:* This water body is delineated as the main confluence section of the river flow, as well as the presence of AWB. The total water body length is 14.7 km.

WB-33. *Left-bank Giratagh and Shgharshik tributaries of the Voghji River:* This water body is delineated as the main confluence section of the river flow taking into consideration hydromorphological and hydrological characteristics and presence of WBR. The total water body length is 15.8 km.

WB-34. *The Kavart River, from the headwaters to Kapan Copper-Molybdenum mine:* This water body is delineated taking into consideration hydromorphological and hydrological characteristics and presence of WBR. The total water body length is 1.7 km.

WB-35. *The Vachagan River, from the headwaters to the Kapan town:* This water body is delineated taking into consideration hydromorphological and hydrological characteristics and presence of WBR. The total water body length is 10.1 km.

WB-36. *The Geghanush River from the headwaters to the Geghanush tailing dam:* This water body is delineated taking into consideration hydromorphological and hydrological characteristics and presence of WBR. The total water body length is 23.4 km.

WB-37. *The Norashenik River, from the headwaters to the Achanan settlement:* This water body is delineated taking into consideration hydromorphological and hydrological characteristics and presence of WBR. The total water body length is 44.7 km.

WB-38. *The Artsvanik River, from headwaters to the Artsvanik tailing dam:* This water body is delineated taking into consideration hydromorphological and hydrological characteristics and presence of WBR. The total water body length is 20.6 km.

WB-39. *The Artsvanik River, from the Artsvanik tailing dam to the river mouth:* This water body is delineated taking into consideration the presence of HMWB. The total water body length is 2 km.

WB-40. *The Syunik River:* This water body is delineated as the main confluence section of the river flow and taking into consideration the presence of WBR. The total water body length is 15.6 km.

WB-41. *The Shikahogh River:* This water body is delineated as the main confluence section of the river flow. The total water body length is 32.2 km.

WB-42. *The Tsav River,* This water body is delineated as the main confluence section of the river flow, as well as delineated taking into consideration hydromorphological and hydrological characteristics. The total water body length is 65.6 km.

WB-43. *The Meghriget River, from headwaters to the Lichk village:* This water body is delineated taking into consideration hydromorphological. The total water body length is 9.6 km.

WB-44. *The Ayriget River*: This water body is delineated taking into consideration the presence of WBR. The total water body length is 10.9 km.

WB-45. *The Gozgoz River, together with the Tashtun tributary:* This water body is delineated as the main confluence section of the river flow, as well as delineated taking into consideration hydromorphological and hydrological characteristics. The total water body length is 44.8 km.

WB-46. *The Kaler River:* This water body is delineated taking into consideration hydromorphological and hydrological characteristics. The total water body length is 10.5 km.

WB-47. *The Mulk River and tributary to the south:* This water body is delineated taking into consideration hydromorphological and hydrological characteristics. The total water body length is 13.8 km.

WB-48. *The Meghriget River, from confluence of the Gozgoz tributary and to the Tkhkut village:* This water body is delineated taking into consideration the presence of WBR. The total water body length is 5.5 km.

WB-49. *The Boghakar River, from headwaters to the Karchevan canal:* This water body is delineated taking into consideration the presence of WBR. The total water body length is 7.4 km.

WB-50. *The Boghakar River, from the Karchevan canal to the river mouth:* This water body is delineated taking into consideration the presence of AWB and WBR. The total water body length is 7.4 km.

WB-51. *The Vardanidzor River:* This water body is delineated taking into consideration the presence of WBR, as well as hydromorphological and hydrological characteristics. The total water body length is 12.2 km.

WB-52. *The Meghriget River, right side Vahravar and Agarak tributaries:* This water body is delineated taking into consideration hydromorphological and hydrological characteristics. The total water body length is 19.4 km.

WB-53. *The Meghriget River, left side tributary in the Meghri town:* This water body is delineated taking into consideration the presence of WBR, as well as hydromorphological and hydrological characteristics. The total water body length is 20.1 km.

WB-54. *The Meghriget River, from the Meghri town to the river mouth*: This water body is delineated taking into consideration the presence of WBR. The total water body length is 1.7 km.

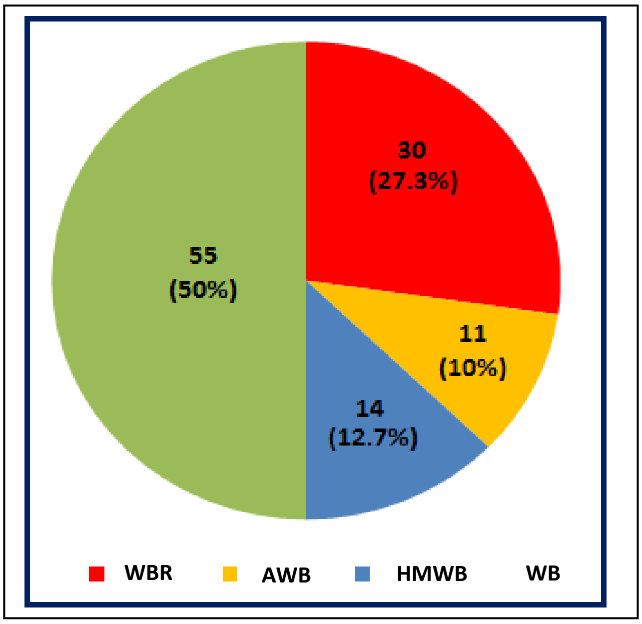
WB-55. *The Karchevan River, from headwaters to the Karchevan village*: This water body is delineated taking into consideration the presence of WBR, as well as hydromorphological and hydrological characteristics. The total water body length is 4.1 km.

4.1.6. All Delineated Surface Water Bodies in the Southern BMA

In general, **110** surface water bodies were identified and delineated in the Southern BMA, of which

- **30** are water bodies at risk – with total length of **194.1 km;**
- **11** are artificial water bodies (water canals) - with total length of **153.4 km**;
- **14** are heavily modified water bodies, including **7** reservoirs, **3** tailing ponds, **3** re-cultivated tailing ponds, **1** group of mining dump sites with **total area of 22.4 km^2;**
- **55** are delineated other natural water bodies, including **54** rivers (river sections, with total length in **1379.6 km** in total length) and **1** natural lake.

The list of surface water bodies delineated in the Southern BMA is presented in Annex D and the map is shown in Figure 4.4.



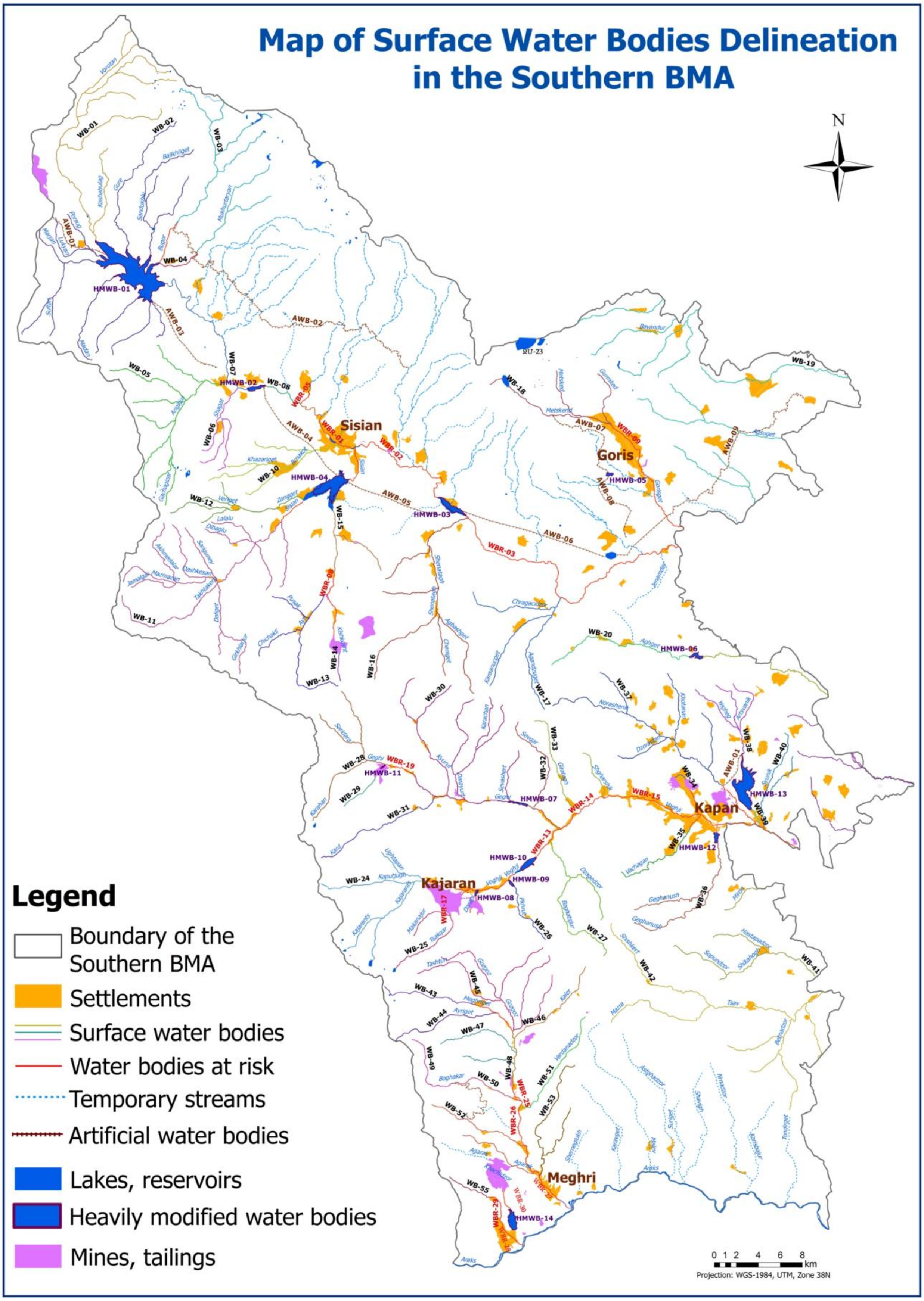


Figure 4.4: Delineated water bodies in the Southern BMA

Source: USAID Clean Energy and Water Program, 2015

4.2. Delineation of Groundwater Bodies

4.2.1. Criteria and Procedure of Delineation of Water Bodies

According to Article 2.12 of the WFD, "Groundwater Body" (GWB) means a distinct volume of groundwater within an aquifer or aquifers. The first step in the process of determining groundwater bodies is analysis of groundwater aquifers having significant groundwater flow and/or significant water abstraction volumes. According to the WFD, "a significant flow of groundwater is one that, were it from reaching an associated surface water body or a directly dependent terrestrial ecosystem, would result in a significant diminution in the ecological or chemical quality of that surface water body or significant damage to the directly dependent terrestrial ecosystems".

According to Article 7 of the WFD, it is required to identify all bodies of groundwater used for the abstraction of water intended for human consumption, and abstraction for such purposes shall be at least 10 m^3 a day as an average. In identification of water bodies, such volume is considered as significant groundwater quantity. The geological strata capable to provide water of such volume are qualified as aquifers. Almost all aquifers with capacity exceeding 10 m^3 per day should be analyzed in terms of delineation of groundwater bodies.

While WFD does not recommend any clear approach for delineation of groundwater bodies, it defines that delineation of groundwater bodies should ensure the achievement of appropriate Directive objectives. This means that delineation should be conducted so as to ensure appropriate description of quantitative and chemical status of groundwater. In many cases the qualitative status can be assessed only, where long-term monitoring data is available. In other cases, availability of groundwater volumes shall be assessed through calculation of water balance.

WFD CIS Guidance Document No. 2 (Identification of Water Bodies) recommends the following sequential steps for identification of groundwater bodies:

- The starting point for identifying the geographical boundaries of a groundwater body should be geological boundaries to flow.
- Sub-divisions of an aquifer or aquifers that cannot be based on geological boundaries should be based initially on groundwater highs or, where necessary, on groundwater flow lines.
- The bodies should be units of one chemical and one quantitative status that can be characterized and managed to allow the effective achievement of the Directive objectives. Major changes in the status of groundwater should therefore be taken into account when delineating groundwater body boundaries to ensure that, as far as practical, an accurate description of groundwater status is ensured. Where status is consistent, large bodies of groundwater may be delineated.
- When delineating the bodies of groundwater, vulnerability of aquifers must be taken into account, i.e. characterization of geological stratus of the overlaying strata shall be conducted.
- Bodies of groundwater could be identified either separately within different strata overlying each other in the vertical plane, or as a single body of groundwater spanning the different strata.
- While delineating groundwater resources, it is necessary to assess surface water - groundwater interaction. Ecosystems of surface water that depend on groundwater could be adversely affected indirectly because of river flow reduction resulting from groundwater abstraction. On the other hand, groundwater level increase can also pose a risk to terrestrial ecosystems, especially in such locations that are covered with such vegetation that is not adapted to high groundwater level.
- Deep groundwater cannot be identified as groundwater bodies, if it:
  - has no adverse impacts on surface water bodies;
  - is not used for groundwater abstraction;
  - is not suitable for drinking water supply because of its natural quality or because its abstraction would be technically unfeasible or disproportionately expensive.

When delineating the Southern BMA groundwater bodies, the following recommendations of the WFD were taken into account:

- Aquifers of various types (porous, sedimentary, volcanic) were distinguished from the hydrogeological map;
- Geological boundaries of aquifers were determined;
- Hydrodynamic differences of aquifers were analyzed;
- Hydrochemical diversity of aquifers was assessed;
- Groundwater abstraction was checked and determined (>10 m^3/day);
- Groundwater system consisting of several shallow aquifers with similar hydrodynamic and hydrochemical characteristics were considered as a single water body;
- Hydrogeological units with the same chemical and a single quantitative status were defined as groundwater bodies;
- The bottom boundary of GWB was determined with such depth, from which groundwater lifting to production processes (not much cost intensive) is still realistic;
- Division of aquifers into numerous unmanageable water bodies were taken into account and small groundwater bodies with similar characteristics were grouped;
- GWBs were given temporary numbers – G01, G02, etc., where G means “Ground” and 01, 02, etc. are the numbers of bodies;
- All identified groundwater bodies were attributed to the Vorotan, Voghji and Meghriget River Basins in the Southern BMA.

4.2.2. General Delineation of Groundwater Bodies in the Southern BMA

Based on the hydrogeological map of the Southern Basin as developed at the Hydrogeological Monitoring Center of the RA MNP and according to the EU WFD, six major hydrogeological units (aquifers) were distinguished in the Vorotan, Voghji and Meghriget River Basins within the Southern BMA:

- Upper quaternary-contemporary (Q3-4) river ravine formations (Meghriget River Basin);
- Powerful flows of andesites-basalt composition of the Syunik quaternary lava flow (Q) (Vorotan River Basin);
- Tuff lava of andesites and andesites-dacite composition (N1, P2, J, D) (Vorotan and Voghji River Basins);
- Carbonate sedimentary rocks (K, J, S-D), (Vorotan and Voghji River Basins);
- Eluvial-deluvial and fractured intrusive rock complex, (P2-Q), (Meghriget River Basin);
- Water saturated tectonic fault zones (PZ- P2).

Based on the results of the analysis of these aquifers, 19 groundwater bodies were identified in the Southern BMA (Table 4.1, Figure 4.5).

Geological boundaries of aquifers were determined, and qualitative groundwater characteristics were provided. Temporary numbers were given to the groundwater bodies.

All groundwater bodies are used for water supply for drinking, agricultural and industrial use.

Quantitative and chemical status of delineated water bodies correspond to the Good groundwater quality class.

Table 4.1: Groundwater bodies identified in the Southern BMA

Name of the aquifer	Water bearing rocks	Quantity of GWBs	Number of GWB
River ravine formations (Q_{3-4})	River stone- boulder, sand	3	G16, G17,G18,
Syunik lava flow (Q)	Powerful andesite-basalt lava flows; in concaves – conglomerates, slightly cemented sandstones, interchange of lake diatomaceous shale and pumice and ashy formations	1	G01

Name of the aquifer	Water bearing rocks	Quantity of GWBs	Number of GWB
Tuff lava of andesite and andesite-dacite composition (N_1, ₽$_2$, J, D)	Tuff breccias, tuff conglomerates that are interchanged in some places with lava flows of the same composition	6	G02, G03, G05, 07,G09, G10
Carbonate sedimentary rocks (K, J, S-D)	Limestone, limestone sandstones, chalky clay	3	G04, G06, G08
Eluvial-deluvial and fractured intrusive rock complex (₽$_2$-Q)	Eluvial-deluvial light fragmental formations, fractured monzodiorite	4	G11, G14, G15, G19
Water saturated tectonic fault zones (PZ-₽$_2$)	Contact zone of intrusive bodies and modified Paleozoic rocks; erosion cracks of intrusive bodies	2	G12, G13
Total		**19**	

Source: USAID Clean Energy and Water Program, 2015

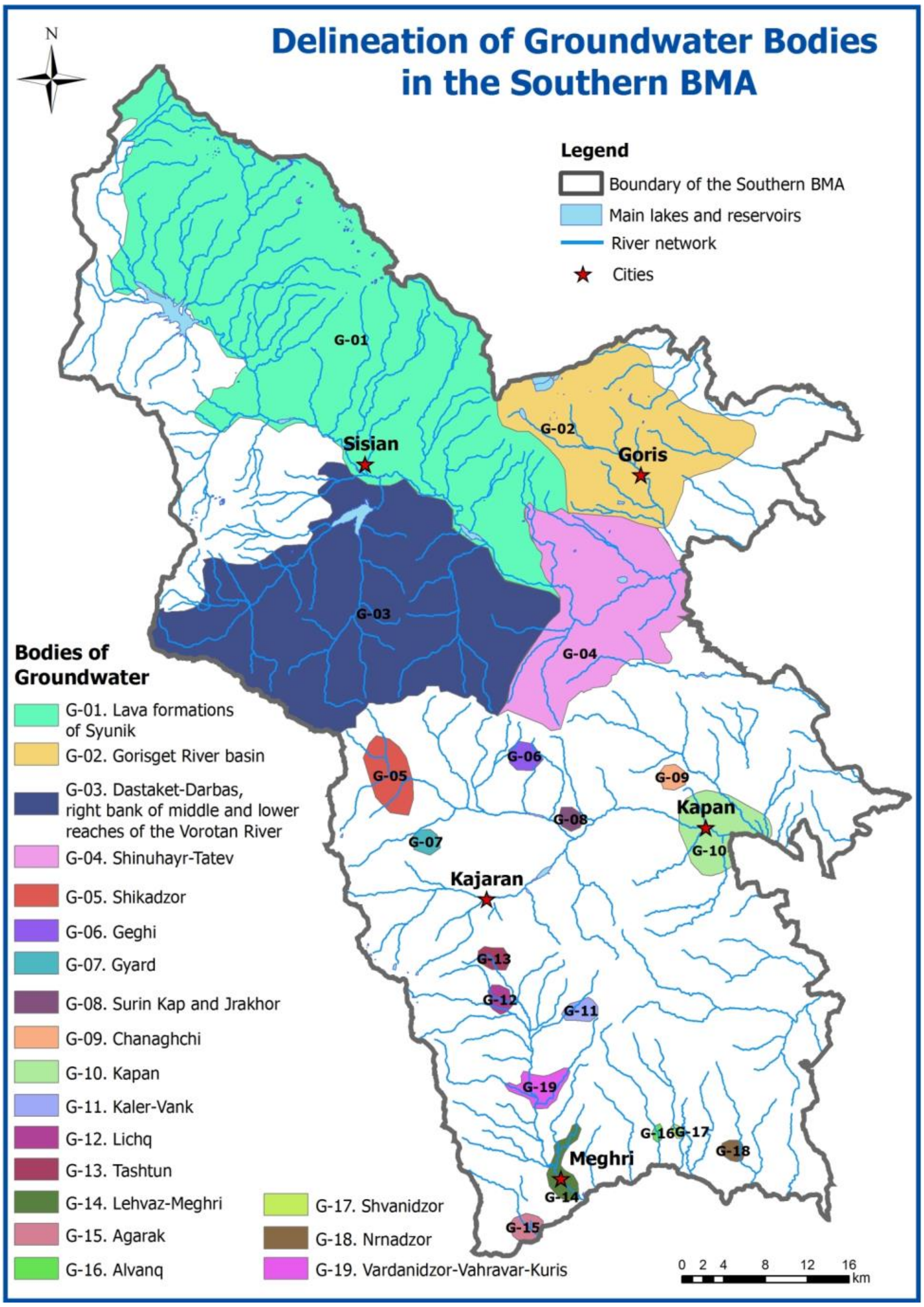


Figure 4.5: Delineation of groundwater bodies in the Southern BMA

Source: USAID Clean Energy and Water Program, 2015

Characterization of 19 groundwater bodies identified in the Southern BMA is presented in Annex E.

CHAPTER 5: DETERMINING ECOLOGICAL FLOW FOR WATER BODIES IN THE SOUTHERN BASIN

5.1. Principles and Particularities of Ecological Flow Determination in Rivers of the Southern BMA

One of the factors for assessing the ecological status of water bodies in the basin is ecological flow. This is a minimum water flow to be maintained in rivers, lakes and reservoirs for ensuring the ecological balance and self-recovery capability of aquatic and terrestrial ecosystems. Volumes of the ecological flow for separate surface water bodies are defined on an annual and monthly basis, given hydrological, hydromorphological, hydrochemical and hydrobiological features of the water body.

5.2. Method of Determining Ecological Flow for the Southern BMA Water Bodies

Ecological flow for water resources in the Republic of Armenia is calculated in accordance with the method approved by the RA Government Decree No. 927-N adopted on 2011 that defines methods for assessment of water demand for drinking-household and agricultural purposes, as well as calculation of ecological flow by basin management areas of Armenia.

According to that method the value of ecological flow/environmental flow for rivers with multiyear water flow observations is defined by taking the lowest average minimum flow observed in the given river during 10 consecutive days in a winter season.

The map of flow module for 10 consecutive days with minimum flows during a low water winter period from the hydrological atlas, prepared by A. B. Baghdasaryan and published in 1990, is used for rivers that have not been observed.

At the time of preparing this management plan, a new method has been in process of development for calculation of the values of ecological flow rivers using integrated approach. The method is based on application of hydrological, hydromorphological, hydrochemical and hydrobiological parameters in the process of determining the ecological flow. After adoption of the new method, volumes of ecological flows for the rivers of the Southern BMA shall be revised.

5.3. Calculation of Ecological Flow in the Southern BMA Rivers, and Comparison of Ecological Flow with Actual Flow

Calculation of annual values of the ecological flow in the rivers of the Southern BMA were conducted for major rivers of the Vorotan, Voghji and Meghriget River Basins, having datasets from operational and closed hydrological observation points (Table 5.1).

Table 5.1: Annual values of ecological flow at the hydrological points of the rivers in the Southern BMA, m^3/sec.

River basin	River- hydrological point	Ecological flow
Vorotan	Vorotan-Gorhayk	1.25
	Vorotan-Angeghakot	2.06
	Vorotan-Vorotan	2.40
	Vorotan-Tatev HPP	3.80
	Tsghuk-Tsghuk	0.18
	Sisian-Arevis	0.17
	Sisian-Ashotavan	0.35
	Loradzor-Ltsen	0.11
	Tatev-Tatev	0.14

River basin	River- hydrological point	Ecological flow
	Gorisget-Goris	0.21
Voghji	Voghji-Kajaran	0.18
	Voghji-Kapan	0.95
	Geghi-Geghi	0.48
	Geghi-Kavchut	0.60
	Geghanush-Geghanush	0.055
	Norashenik-Norashenik	0.04
	Vachagan-Kapan	0.053
Meghriget	Meghriget-Lichk	0.02
	Meghriget-Meghri	017

Source: Armenian State Hydrometeorological and Monitoring Service SNCO of the RA MTAES

Based on the calculated annual values of ecological flow, monthly values of ecological flow were calculated at the hydrological observations points of the basin. Monthly values were calculated as percentage ratio of the calculated annual values of ecological flow and observed multiyear minimum monthly flow values. Generated monthly values of the ecological flow were compared with multiyear average values of actual flows of the same rivers (Table 5.2).

Table 5.2: Comparison of values of multiyear average actual flow and calculated ecological flow in the rivers of the Southern BMA

River-hydrological point	River flow, m^3/sec	Months											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Vorotan River Basin													
Vorotan-Gorhayk	*Average monthly flow*	2.06	2.07	2.27	4.78	10.7	8.98	4.03	2.64	2.32	2.12	2.04	2.02
	Ecological flow	1.38	1.25	1.52	3.09	7.15	5.81	2.69	1.77	1.50	1.42	1.32	1.35
	Difference	**0.68**	**0.82**	**0.75**	**1.69**	**3.55**	**3.17**	**1.34**	**0.87**	**0.82**	**0.70**	**0.72**	**0.67**
Vorotan-Angeghakot	*Average monthly flow*	17.4	15.7	8.67	11.2	10.8	11.5	11.3	11.9	10.6	11.9	14.6	15.9
	Ecological flow	2.06	2.53	4.13	3.31	3.32	3.22	3.17	3.01	3.49	3.01	2.54	2.25
	Difference	**15.34**	**13.17**	**4.54**	**7.89**	**7.48**	**8.28**	**8.13**	**8.89**	**7.11**	**8.89**	**12.06**	**13.65**
Vorotan-Vorotan	*Average monthly flow*	3.97	4.48	4.90	7.70	6.62	5.49	5.04	4.98	5.24	4.89	4.43	4.12
	Ecological flow	2.40	2.45	2.96	4.51	4.00	3.21	3.05	3.01	3.07	2.96	2.59	2.49
	Difference	**1.57**	**2.03**	**1.94**	**3.19**	**2.62**	**2.28**	**1.99**	**1.97**	**2.17**	**1.93**	**1.84**	**1.63**
Vorotan-Tatev HPP	*Average monthly flow*	20.3	18.8	17.9	26.0	23.6	23.7	16.7	17.9	17.7	18.3	18.2	18.8
	Ecological flow	4.54	3.80	4.01	5.63	5.28	5.13	3.74	4.01	3.83	4.10	3.94	4.21
	Difference	**15.76**	**15.00**	**13.89**	**20.37**	**18.32**	**18.57**	**12.96**	**13.89**	**13.87**	**14.2**	**14.26**	**14.59**
Tsghuk-Tsghuk	*Average monthly flow*	0.66	0.60	0.63	1.78	6.16	4.60	0.85	0.31	0.32	0.40	0.70	0.71
	Ecological flow	0.22	0.18	0.21	0.57	2.05	1.48	0.28	0.10	0.10	0.13	0.23	0.24
	Difference	**0.44**	**0.42**	**0.42**	**1.21**	**4.11**	**3.12**	**0.57**	**0.21**	**0.22**	**0.27**	**0.48**	**0.47**
Sisian - Arevis	*Average monthly flow*	0.57	0.55	0.84	3.31	6.34	4.08	1.58	0.9	0.78	0.9	0.9	0.73
	Ecological flow	0.20	0.17	0.29	1.10	2.17	1.35	0.54	0.31	0.26	0.31	0.30	0.25
	Difference	0.37	0.38	0.55	2.21	4.17	2.73	1.04	0.59	0.52	0.59	0.60	0.48
Sisian-Ashotavan	*Average monthly flow*	0.76	0.91	1.37	4.85	8.89	7.96	2.34	0.82	0.54	0.67	0.83	0.85
	Ecological flow	0.35	0.38	0.63	2.16	4.09	3.55	1.08	0.38	0.37	0.40	0.37	0.39
	Difference	0.41	0.53	0.74	2.69	4.80	4.41	1.26	0.44	0.17	0.27	0.46	0.46
Loradzor-Ltsen	*Average monthly flow*	0.36	0.37	0.5	1.55	3.07	2.05	0.84	0.45	0.45	0.48	0.48	0.41
	Ecological flow	0.12	0.11	0.16	0.49	1.01	0.65	0.28	0.15	0.14	0.16	0.15	0.13
	Difference	0.24	0.26	0.34	1.06	2.06	1.40	0.56	0.30	0.31	0.32	0.33	0.28
Tatev-Tatev	*Average monthly flow*	0.52	0.53	0.87	2.62	3.56	3.03	1.31	0.76	0.68	0.69	0.68	0.58

River-hydrological point	River flow, m^3/sec	Months											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
	Ecological flow	0.15	0.14	0.25	0.74	1.04	0.86	0.38	0.22	0.19	0.20	0.19	0.17
	Difference	0.37	0.39	0.62	1.88	2.52	2.17	0.93	0.54	0.49	0.49	0.49	0.41
Gorisget-Goris	*Average monthly flow*	0.39	0.41	0.47	0.64	0.73	0.52	0.25	0.27	0.37	0.40	0.38	0.36
	Ecological flow	0.13	0.13	0.16	0.21	0.25	0.17	0.08	0.09	0.12	0.14	0.13	0.12
	Difference	0.26	0.28	0.31	0.43	0.48	0.35	0.16	0.18	0.25	0.26	0.26	0.24
Voghji River Basin													
Voghji-Kajaran	*Average monthly flow*	0.54	0.56	0.82	3.15	7.99	11.97	7.56	2.69	1.06	0.72	0.66	0.57
	Ecological flow	0.18	0.50	0.73	2.79	7.09	10.63	6.70	2.4	0.96	0.65	0.59	0.5
	Difference	0.36	0.06	0.09	0.36	0.90	1.34	0.86	0.30	0.10	0.07	0.07	0.07
Voghji-Kapan	*Average monthly flow*	2.47	2.72	4.99	15.82	32.00	31.28	16.59	6.63	4.03	3.84	3.43	2.81
	Ecological flow	0.95	0.97	1.85	4.94	6.53	3.89	2.09	1.62	1.30	1.66	1.53	1.26
	Difference	1.52	1.75	3.14	10.87	25.47	27.39	14.50	5.01	2.73	2.18	1.90	1.55
Geghi-Geghi	*Average monthly flow*	1.56	1.55	1.96	5.56	12.91	13.70	7.62	3.61	2.40	2.11	1.87	1.68
	Ecological flow	0.48	0.48	0.66	1.38	3.65	0.84	0.88	0.79	0.83	0.56	0.50	0.50
	Difference	1.08	1.07	1.30	4.18	9.26	12.87	6.74	2.82	1.57	1.55	1.37	1.18
Geghi Kavchut	*Average monthly flow*	0.95	0.99	1.70	6.42	13.31	13.12	6.88	2.82	1.56	1.44	1.28	1.09
	Ecological flow	0.40	0.38	0.62	2.11	5.85	4.93	2.43	0.99	0.67	0.52	0.47	0.43
	Difference	0.55	0.61	1.08	4.31	7.46	8.19	4.45	1.83	0.89	0.92	0.81	0.66
Geghanush-Geghanush	*Average monthly flow*	0.21	0.23	0.69	1.90	1.85	0.92	0.43	0.29	0.31	0.26	0.28	0.23
	Ecological flow	0.06	0.06	0.25	0.29	0.31	0.15	0.08	0.07	0.07	0.09	0.07	0.06
	Difference	0.15	0.17	0.44	1.61	1.54	0.77	0.35	0.22	0.24	0.17	0.21	0.17
Norashenik-Norashenik	*Average monthly flow*	0.41	0.46	1.20	2.67	2.35	1.63	0.89	0.57	0.66	0.64	0.58	0.46
	Ecological flow	0.04	0.04	0.26	0.78	0.58	0.21	0.09	0.12	0.08	0.12	0.11	0.08
	Difference	0.37	0.42	0.94	1.89	1.77	1.42	0.80	0.45	0.58	0.52	0.47	0.38
Vachagan-Kapan	*Average monthly flow*	0.21	0.23	0.69	1.89	1.81	0.89	0.32	0.28	0.30	0.25	0.27	0.22
	Ecological flow	0.05	0.08	0.13	0.18	0.17	0.08	0.06	0.07	0.07	0.08	0.08	0.07
	Difference	0.16	0.15	0.56	1.71	1.64	0.81	0.26	0.21	0.23	0.17	0.19	0.15
Meghriget River Basin													
Meghriget-Lichk	*Average monthly flow*	0.09	0.09	0.13	0.47	1.32	2.41	1.53	0.52	0.19	0.14	0.13	0.11
	Ecological flow	0.02	0.02	0.03	0.15	0.65	1.18	0.46	0.13	0.06	0.03	0.03	0.03
	Difference	0.07	0.07	0.10	0.32	0.67	1.23	1.07	0.39	0.13	0.11	0.10	0.08
Meghriget-Meghri	*Average monthly flow*	0.89	0.97	2.01	5.37	7.66	8.28	4.21	1.36	0.77	0.92	1.08	0.96
	Ecological flow	0.26	0.17	0.52	1.09	1.66	2.49	0.87	0.40	0.36	0.33	0.34	0.28
	Difference	0.63	0.80	1.49	4.28	6.00	5.79	3.34	0.96	0.41	0.59	0.74	0.68

Source: Armenian State Hydrometeorological and Monitoring Service SNCO of the RA MTAES

The comparison of values of ecological flow and multiyear average actual flow in the rivers of the Southern BMA as presented in Table 5.2 shows that ecological flow is maintained at all hydrological observation points.

5.4. Comparison of Values of the Actual Minimum and Calculated Ecological Flows in the Rivers of the Southern BMA

The comparison of values of observed actual minimum flow and calculated ecological flow in the rivers of the Southern BMA is presented in Table 5.3.

Table 5.3: Comparison of values of observed actual minimum flow and calculated ecological flow in the rivers of the Southern BMA

River-hydrological point	River flow, m^3/sec.	Months											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Vorotan River Basin													
Vorotan-Gorhayk	Actual minimum flow	1.83	1.84	2.08	3.26	7.9	5.89	2.97	1.85	1.68	1.75	1.7	1.68
	Ecological flow	1.38	1.25	1.52	3.09	7.15	5.81	2.69	1.77	1.5	1.42	1.32	1.35
	Difference	**0.45**	**0.59**	**0.56**	**0.17**	**0.75**	**0.08**	**0.28**	**0.08**	**0.18**	**0.33**	**0.38**	**0.33**
Vorotan-Angeghakot	Actual minimum flow	0.92	1.09	1.13	2.28	2.06	3.03	2.58	1.73	1.48	1.38	1.32	0.90
	Ecological flow	2.06	2.53	4.13	3.31	3.32	3.22	3.17	3.01	3.49	3.01	2.54	2.25
	Difference	**-1.14**	**-1.44**	**-3.00**	**-1.03**	**-1.26**	**-0.19**	**-0.59**	**-1.28**	**-2.01**	**-1.63**	**-1.22**	**-1.35**
Vorotan - Vorotan	Actual minimum flow	2.46	2.76	1.82	1.93	2.25	1.94	1.76	1.64	1.85	1.68	1.61	1.54
	Ecological flow	2.40	2.45	2.96	4.51	4.00	3.21	3.05	3.01	3.07	2.96	2.59	2.49
	Difference	**0.06**	**0.31**	**-1.14**	**-2.58**	**-1.75**	**-1.27**	**-1.29**	**-1.37**	**-1.22**	**-1.28**	**-0.98**	**-0.95**
Vorotan – Tatev HPP	Actual minimum flow	12.20	4.06	6.39	7.71	4.03	4.82	4.29	3.59	7.21	4.82	3.52	8.22
	Ecological flow	4.54	3.80	4.01	5.63	5.28	5.13	3.74	4.01	3.83	4.10	3.94	4.21
	Difference	**7.66**	**0.26**	**2.38**	**2.08**	**-1.25**	**-0.31**	**0.55**	**-0.42**	**3.38**	**0.72**	**-0.42**	**4.01**
Tsghuk-Tsghuk	Actual minimum flow	0.39	0.35	0.36	0.58	2.39	0.61	0.11	0.05	0.05	0.07	0.21	0.26
	Ecological flow	0.22	0.18	0.21	0.57	2.05	1.48	0.28	0.10	0.10	0.13	0.23	0.24
	Difference	**0.17**	**0.17**	**0.15**	**0.01**	**0.34**	**-0.87**	**-0.17**	**-0.05**	**-0.05**	**-0.06**	**-0.02**	**0.02**
Sisian-Arevis	Actual minimum flow	0.23	0.24	0.37	1.11	2.22	1.81	0.61	0.41	0.3	0.32	0.34	0.33
	Ecological flow	0.20	0.17	0.29	1.10	2.17	1.35	0.54	0.31	0.26	0.31	0.30	0.25
	Difference	0.03	0.07	0.08	0.01	0.05	0.46	0.07	0.10	0.04	0.01	0.04	0.08
Sisian-Ashotavan	Actual minimum flow	0.41	0.41	0.52	1.8	3.96	1.32	0.19	0.17	0.22	0.38	0.34	0.49
	Ecological flow	0.35	0.38	0.63	2.16	4.09	3.55	1.08	0.38	0.37	0.40	0.37	0.39
	Difference	**0.06**	**0.03**	**-0.11**	**-0.36**	**-0.13**	**-2.23**	**-0.89**	**-0.21**	**-0.15**	**-0.02**	**-0.03**	**0.10**
Loradzor-Ltsen	Actual minimum flow	0.15	0.14	0.25	0.52	1.02	0.71	0.29	0.16	0.15	0.19	0.19	0.2
	Ecological flow	0.12	0.11	0.16	0.49	1.01	0.65	0.28	0.15	0.14	0.16	0.15	0.13
	Difference	**0.03**	**0.03**	**0.09**	**0.03**	**0.01**	**0.06**	**0.01**	**0.01**	**0.01**	**0.03**	**0.04**	**0.07**
Tatev-Tatev	Actual minimum flow	0.26	0.31	0.34	0.79	1.16	0.94	0.49	0.23	0.24	0.37	0.37	0.36
	Ecological flow	0.15	0.14	0.25	0.74	1.04	0.86	0.38	0.22	0.19	0.20	0.19	0.17
	Difference	**0.11**	**0.17**	**0.09**	**0.05**	**0.12**	**0.08**	**0.11**	**0.01**	**0.05**	**0.17**	**0.18**	**0.19**
Gorisget-Goris	Actual minimum flow	0.13	0.13	0.17	0.25	0.25	0.09	0.03	0.04	0.09	0.10	0.13	0.13
	Ecological flow	0.13	0.13	0.16	0.21	0.25	0.17	0.08	0.09	0.12	0.14	0.13	0.13
	Difference	**0.00**	**0.00**	**0.01**	**0.04**	**0.00**	**-0.08**	**-0.05**	**-0.05**	**-0.03**	**-0.04**	**0.00**	**0.00**
Voghji River Basin													
Voghji-Kajaran	Actual minimum flow	0.001	0.001	0.017	0.73	2.97	3.3	1.0	0.001	0.001	0.001	0.001	0.001
	Ecological flow	0.18	0.18	0.19	0.83	2.81	3.12	1.09	0.20	0.18	0.18	0.18	0.18
	Difference	**-0.18**	**-0.18**	**-0.17**	**-0.10**	**0.16**	**0.18**	**-0.09**	**-0.20**	**-0.18**	**-0.18**	**-0.18**	**-0.18**
Voghji-Kapan	Actual minimum flow	0.56	0.58	1.7	5.09	6.82	3.67	1.58	1.04	0.77	1.07	1.16	0.82
	Ecological flow	0.95	0.97	1.85	4.94	6.53	3.89	2.09	1.62	1.30	1.66	1.53	1.26
	Difference	**-0.39**	**-0.39**	**-0.15**	**0.15**	**0.29**	**-0.22**	**-0.51**	**-0.58**	**-0.53**	**-0.59**	**-0.37**	**-0.44**
Geghi-Geghi	Actual minimum flow	0.6	0.6	1.01	1.83	6.58	4.78	2.42	1.39	1.09	0.71	0.63	0.63
	Ecological flow	0.48	0.48	0.66	1.38	3.65	0.84	0.88	0.79	0.83	0.56	0.50	0.50
	Difference	**0.12**	**0.12**	**0.35**	**0.45**	**2.93**	**3.94**	**1.54**	**0.60**	**0.26**	**0.15**	**0.13**	**0.13**
Geghi-Kavchut	Actual minimum flow	0.6	0.57	0.93	3.17	8.78	7.4	3.65	1.49	1.01	0.78	0.71	0.65
	Ecological flow	0.40	0.38	0.62	2.11	5.85	4.93	2.43	0.99	0.67	0.52	0.47	0.43
	Difference	**0.20**	**0.19**	**0.31**	**1.06**	**2.93**	**2.47**	**1.22**	**0.50**	**0.34**	**0.26**	**0.24**	**0.22**
Geghanush-Geghanush	Actual minimum flow	0.06	0.06	0.28	0.94	0.57	0.12	0.032	0.044	0.05	0.095	0.08	0.06
	Ecological flow	0.06	0.06	0.25	0.29	0.31	0.15	0.08	0.07	0.07	0.09	0.07	0.06
	Difference	**0.01**	**0.01**	**0.03**	**0.65**	**0.26**	**-0.03**	**-0.05**	**-0.02**	**-0.02**	**0.01**	**0.01**	**0.01**
Norashenik-Norashenik	Actual minimum flow	0.28	0.22	0.69	0.93	0.65	0.22	0.24	0.19	0.26	0.33	0.32	0.27

River-hydrological point	River flow, m^3/sec.	Months											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
	Ecological flow	0.04	0.04	0.26	0.78	0.58	0.21	0.09	0.12	0.08	0.12	0.11	0.08
	Difference	**0.24**	**0.18**	**0.43**	**0.15**	**0.07**	**0.01**	**0.15**	**0.07**	**0.18**	**0.21**	**0.21**	**0.19**
Vachagan-Kapan	Actual minimum flow	0.06	0.08	0.04	0.32	0.19	0.1	0.02	0.01	0.01	0.02	0.05	0.04
	Ecological flow	0.05	0.08	0.13	0.18	0.17	0.08	0.06	0.07	0.07	0.08	0.08	0.07
	Difference	**0.01**	**0.00**	**-0.09**	**0.14**	**0.02**	**0.02**	**-0.04**	**-0.06**	**-0.06**	**-0.06**	**-0.03**	**-0.03**
Meghriget River Basin													
Meghriget-Lichk	Actual minimum flow	0.011	0.01	0.017	0.17	0.71	1.24	0.48	0.081	0.032	0.022	0.019	0.019
	Ecological flow	0.02	0.02	0.03	0.15	0.65	1.18	0.46	0.13	0.06	0.03	0.03	0.03
	Difference	**-0.01**	**-0.01**	**-0.01**	**0.02**	**0.06**	**0.06**	**0.02**	**-0.05**	**-0.03**	**-0.01**	**-0.01**	**-0.01**
Meghriget-Meghri	Actual minimum flow	0.31	0.18	0.7	1.49	2.07	3.35	1.02	0.19	0.13	0.21	0.36	0.35
	Ecological flow	0.26	0.17	0.52	1.09	1.66	2.49	0.87	0.40	0.36	0.33	0.34	0.28
	Difference	**0.05**	**0.01**	**0.18**	**0.40**	**0.41**	**0.86**	**0.15**	**-0.21**	**-0.23**	**-0.12**	**0.02**	**0.07**

The comparison of values of actual minimum flow observed and calculated ecological flow in the rivers of the Southern BMA shows that ecological flow is not maintained in a number of sections of rivers due to overuse of water resources (Table 5.3) and as described below:

The Vorotan River Basin: ecological flow is not maintained at the Angeghakot, Vorotan, Tatev HPP hydrological observations points of the Vorotan River and Tsghuk hydrological observation point of the Tsghuk River as a result of water abstractions throughout the year for hydropower generation. At the Ashotavan observation point of the Gorisget and Sisian rivers, the ecological flow is not maintained through the period of summer-autumn due to water extraction for irrigation purposes.

The Voghji River Basin: ecological flow is not maintained at Voghji-Kajaran, Voghji-Kapan, Geghanush-Geghanush and Vachagan-Kapan hydrological observations points as a result of water overuse in summer-autumn and winter periods mainly for industrial purposes and hydropower generation (mostly by SHPPs).

The Meghriget River Basin: ecological flow is not maintained at Meghriget-Lichk hydrological observation point in the period of August-March, and at Meghriget-Meghri hydrological point in the period of August-October due to excessive of water resources for irrigation and hydropower generation.

CHAPTER 6: PROGRAM OF MEASURES TO ACHIEVE DESIRABLE STATUS IN THE SOUTHERN BASIN MANAGEMENT AREA

The desirable status is when environmental objectives are achieved in all water bodies of the basin management area. The environmental objectives are:

- Achieving good water status for those water bodies, where the water status is lower than good, i.e. water bodies at risk;
- Maintaining good or excellent water status in the rest of water bodies.

Measures aimed at the achievement of desirable status in water bodies in the Southern BMA are provided in the following sequence:

- Measures for strengthening legal framework;
- Measures for strengthening institutional framework;
- Technical measures.

6.1. Measures for Strengthening Legal Framework to Achieve Desirable Status

The following measures are proposed for strengthening the legal framework to achieve the desirable status in the Southern BMA, including those that are targeted at adaptation to climate change:

- Provision of the protection regime for the Sev Lich State Sanctuary in compliance with the requirements of the RA Law on Specially Protected Natural Areas;
- Adoption of a new integrated method of calculation of annual, seasonal and monthly values of ecological flow in the rivers based on hydrological, hydromorphological, hydrochemical and hydrobiological parameters and implementation thereof;
- Development of a method of assessment of loads on water resources of the Southern BMA and conducting the assessment;
- Revision of the conditions defined by the water use permits of the SHPPs , including volume and regime of water abstraction, fish passes, etc., and bringing those into conformity with environmental requirements;
- Identification of the zones that are prohibited for construction and operation of SHPPs, including special protected areas, forest areas, landslide zones, hydrological vulnerable areas;
- Development of a method for assessment of self-purification capacity of the rivers, preparation of mechanisms for its enforcement;
- Development of a concept for introduction of model farms, as well as regulations for farms management;
- Introduction of insurance systems and subsidization mechanisms aimed at protection of population of villages that are vulnerable and at risk (e.g. those with less income, settlements that are sensitive/vulnerable to natural disasters) from climate risks and to compensate for damages and losses resulting from natural disasters;
- Planning of effective land use and introduction of construction standards to protect vulnerable population from the impacts of natural disasters;
- Development and adoption of legal, economic and administrative incentives to reduce water losses and promote use of water saving technologies;
- Strengthening supervision mechanisms for enforcement of water use permit conditions, including determination of mechanisms for water allocation between water users during the low-flow seasons and water use optimization;
- Adoption and enforcement of mechanisms for self-monitoring;
- Improvement of the water users' accountability and reporting with a purpose of obtaining data actual on water use, wastewater removal and levels of pollution of water resources;
- Establishment of water resources protection zones and the sanitary requirements thereof in the recreation zones;
- Inclusion of climate risks in development programs of water use sectors;

- Incorporation of climate change adaptation measures in the village and Marz development programs and plans;
- Incorporation of climate change risks in key legal documents related to water resources management (the RA Water Code, RA Laws on National Water Program and Fundamental Provisions of the National Water Policy).

6.2. Measures for Strengthening Institutional Framework to Achieve Desirable Status

The following measures are proposed for strengthening the institutional framework to achieve the desirable status and climate change adaptation in the Southern BMA:

- Strengthening institutional capacities of the Department of Policy on Environmental Impact Assessment and Water Resources Protection, Environmental Impact Expertise Center, WRMA and its basin management organizations, State Environmental Inspectorate and its regional offices of the MNP, including equipping with state-of-the-art equipment and staff training;
- Building capacities of the Environmental Impact Expertise Center of the MNP to conduct hydrobiological and hydrochemical monitoring of water resources and assess ecological status of water resources, including equipping with state-of-the-art equipment and staff training;
- Building institutional capacities of the Hydrogeological Monitoring Center of the MNP, including equipping with state-of-the-art equipment and staff training, as well as expanding the groundwater resources monitoring network;
- Building capacities of the Armenian State Hydrometeorological and Monitoring Service of the RA MTAES to conduct hydrological and hydromorphological monitoring of water resources, including equipping with state-of-the-art equipment and staff training;
- Building capacities of appropriate units of the RA MTAES for the purpose of conducting studies and projections of landslide and erosion phenomena, including furnishing with equipment;
- Providing targeted funding (earmarking) for performing scientific-research works regarding water resources;
- Training the staff of local self-government bodies, farms and ArmForest SNCO of the RA MA to prevent diffuse/non-point pollution of water resources through correct use of fertilizers and forest restoration;
- Establishing Vorotan State Hydrological Reserve SNCO within the RA MNP and building its capacities for the purpose of protecting the flow formation area in upper reaches of the Vorotan River;
- Establishing Voghji State Hydrological Sanctuary and Lichk State Hydrological Sanctuary within the structure of the Zangezur Biosphere Complex of the RA MNP and building their capacity for the purpose of protecting the flow formation area in upper reaches of the Voghji and Meghriget Rivers;
- Establishing Shaqi Hydrological State Sanctuary within the structure of the RA MNP and building its capacities;
- Introducing/improving early warning and rapid response system for hazardous hydrometeorogical occurrences in the Southern BMA, particularly aimed at warning communities on oncoming landslide, mudflow and flood hazards;
- Strengthening data and information exchange and cooperation between key stakeholders and ensuring data accessibility/availability for analytic and research centers and projects via the State Water Cadastre Information System.

6.3. Technical Measures to Achieve Desirable Status

Significant pressures on water resources in agglomerations and settlements outside the agglomerations were analyzed, and appropriate measures were recommended. The technical measures include also those aiming at resilience to climate change. Agglomerations in the Southern BMA were defined in accordance with the EU Urban Wastewater Treatment Directive Guidance document.

To identify agglomerations, large settlements of the Southern BMA with significant pressures on water resources were determined. Settlements incorporated in agglomerations should comply with the following requirements:

- The total length of sewage collector for the recommended settlements should not exceed 15 km (taking into account peculiarities of topography);
- The population density in agglomeration should be at least 30 person/ha;
- The time required for transportation of collected wastewater to a treatment plant should not exceed 6 hours (taking into account daily flow alterations);
- The minimum number of subscribers in the settlements embedded in the agglomeration must be 45 households or equivalent to population of 120 (P.E.) per 1 km of sewage collector.

According to the above stated criteria, 6 agglomerations were identified in the Southern BMA, particularly, Goris, Sisian, Kapan, Kajaran, Meghri and Agarak agglomerations (Table 6.1., Figure 6.1)

Table 6.1: Population in agglomerations of the Southern BMA as of 2014

№	Agglomeration	Area, ha	Agglomeration settlements	Population	Agglomeration population	Person/ha
1	Goris	756	t. Goris v. Verishen v. Akner v. Karahunj v. Hartashen	23261 2314 1087 1254 662	28578	38
2	Sisian	932	t. Sisian v. Shaqi v. Brnakot v. Uyts	16843 1390 2103 453	20789	22
3	Kapan	1354	t. Kapan v. Syunik	43200 1427	44627	3296
4	Kajaran	251	t. Kajaran v. Lernadzor	7200 1095	8295	33
5	Meghri	275	t. Meghri v. Lehvaz	4600 623	5223	19
6	Agarak	168	t. Agarak v. Karchevan	4500 230	5000	28

Goris and Sisian agglomerations were identified based on availability of groundwater in the area and identified significant pressures from communal wastewaters, food industry and livestock breeding.

Kapan agglomeration was identified based on significant pressures in the area posed by communal wastewater, mining industry, solid wastes. Kajaran agglomeration was identified based on significant pressures from industrial water extraction, communal wastewater, mining industry, solid wastes, as well as not maintenance of the ecological flow requirements.

Meghri agglomeration was identified based on significant pressures posed by communal wastewater, solid wastes, food industry and ecological flow disturbance. Agarak agglomeration was separated based on significant pressures from communal wastewater, solid waste and mining industry.

To calculate increase of BOD_5 in wastewater removed from the agglomerations, BOD_5 concentration was calculated, given the population size in settlement and using the norm acceptable for BOD_5 (60g/day*N. where N is population size). Consequently, BOD_5 concentration for each of the agglomerations was calculated by $C =$ ((60g/day*N*1000)/ 24*60*60)/Q_0 mg/l formula, where Q_0 is the river discharge in the given section (Table 6.2).

Table 6.2: BOD_5 increase in the agglomeration of the Southern BMA during the annual minimum flow period

№	Agglomeration	Total population	Wastewater discharged at the pressure point, l/sec	Minimum river flow upstream the pressure point, l/sec	Calculated BOD_5 increase
1	Goris	28578	75	500	66.15
2	Sisian	20789	40	4000	7.73
3	Kapan	44627	70	1090	28.43
4	Kajaran	8295	31	200	28.80
5	Meghri	5223	25	170	90.68
6	Agarak	4730	36	20	164.24

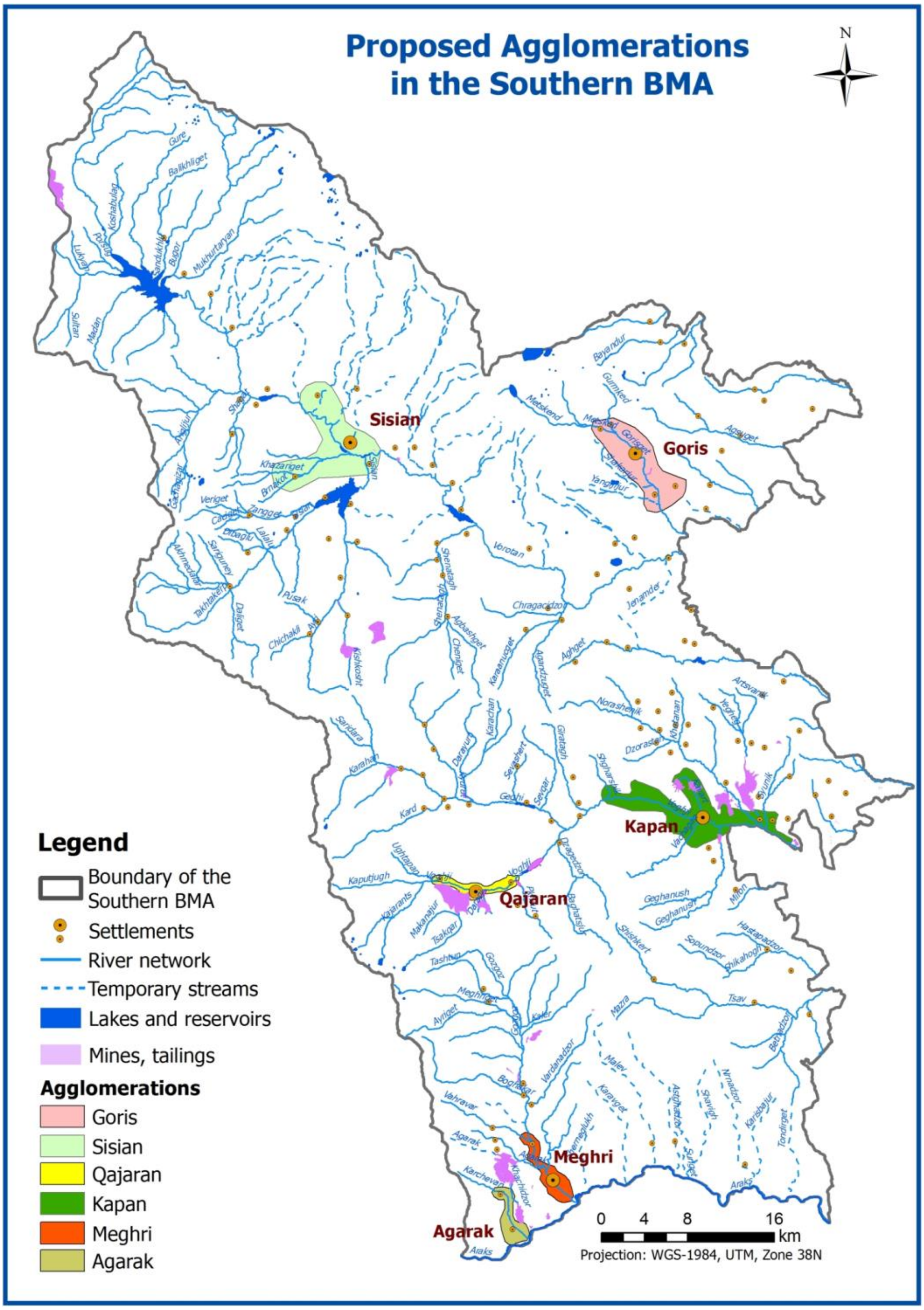


Figure 6.1: Location of agglomerations recommended in the Southern BMA

Source: USAID Clean Energy and Water Program, 2015

Rural settlements included in the agglomerations are not connected to sewerage. Nevertheless, the calculations are made for the total population of agglomerations, in view of the communities' potential coverage with a unified sewerage system in future. According to the RA Syunik Marz Social-Economic Development Program for 2014-2017, small population growth will be observed in the Southern BMA over the next decade.

6.3.1. Potential Location of Wastewater Treatment Plants in Settlements

Potential location of WWTPs in the recommended 6 agglomerations has been determined taking into account the topography and development peculiarities of the area. It is the lowest point of the given agglomeration. Topographically it will ensure wastewater flow to WWTP by gravity.

Goris Agglomeration: Previously, there was no WWTP in the town of Goris. It is proposed to build a WWTP with planned capacity of up to 15000 m^3/day for the Goris agglomeration, 2.6 km downstream the Goris town, the south-east of Karahunj village (Figure 6.2).

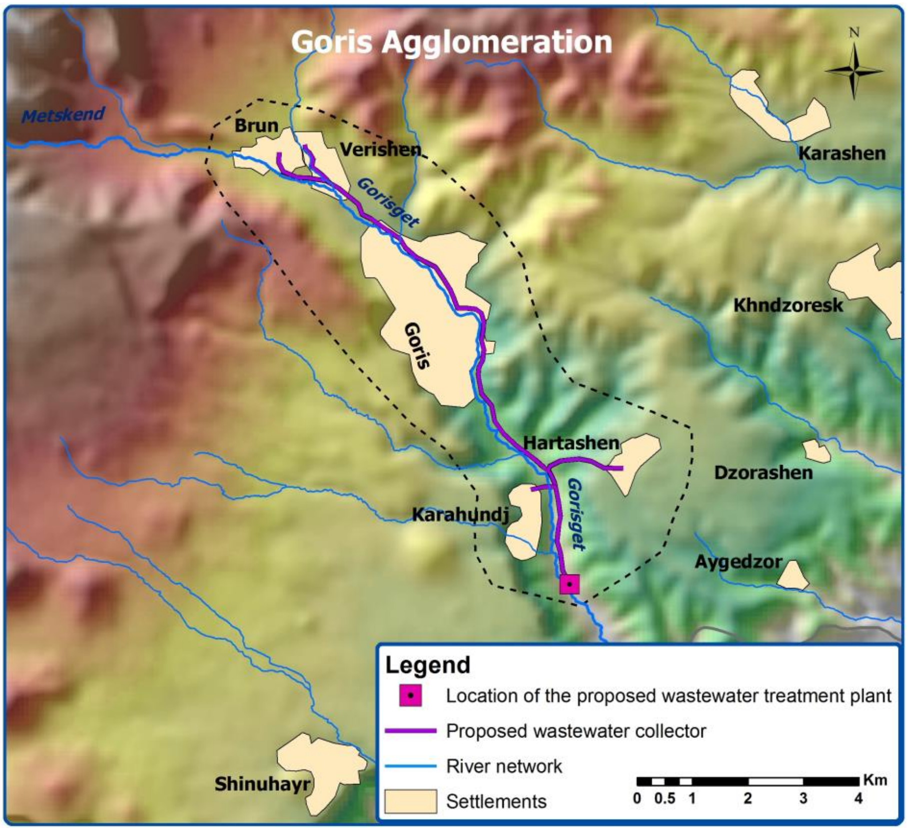


Figure 6.2: Goris agglomeration and recommended location of the WWTP

Source: USAID Clean Energy and Water Program, 2014 (coordinate system WGS. UTM Zone 38N)

Sisian Agglomeration: According to the design estimates for the main collector and WWTP for the town of Sisian, developed by "ArmCommunDesign" Institute, 85% of the total construction work volume was performed by 1990. To deliver wastewater to the treatment plant by gravity, a 1.8 km long tunnel was constructed and collector was installed. However, the works were suspended because of lack of funding.

It is proposed to construct a new WWTP for Sisian agglomeration with planned capacity of 10000 m^3/day in the Vorotan Gorge (in the place of the half-constructed treatment plant that was designed in the past), 2.5 km downstream the town of Sisian, the south-west of Aghitu village (Figure 6.3).

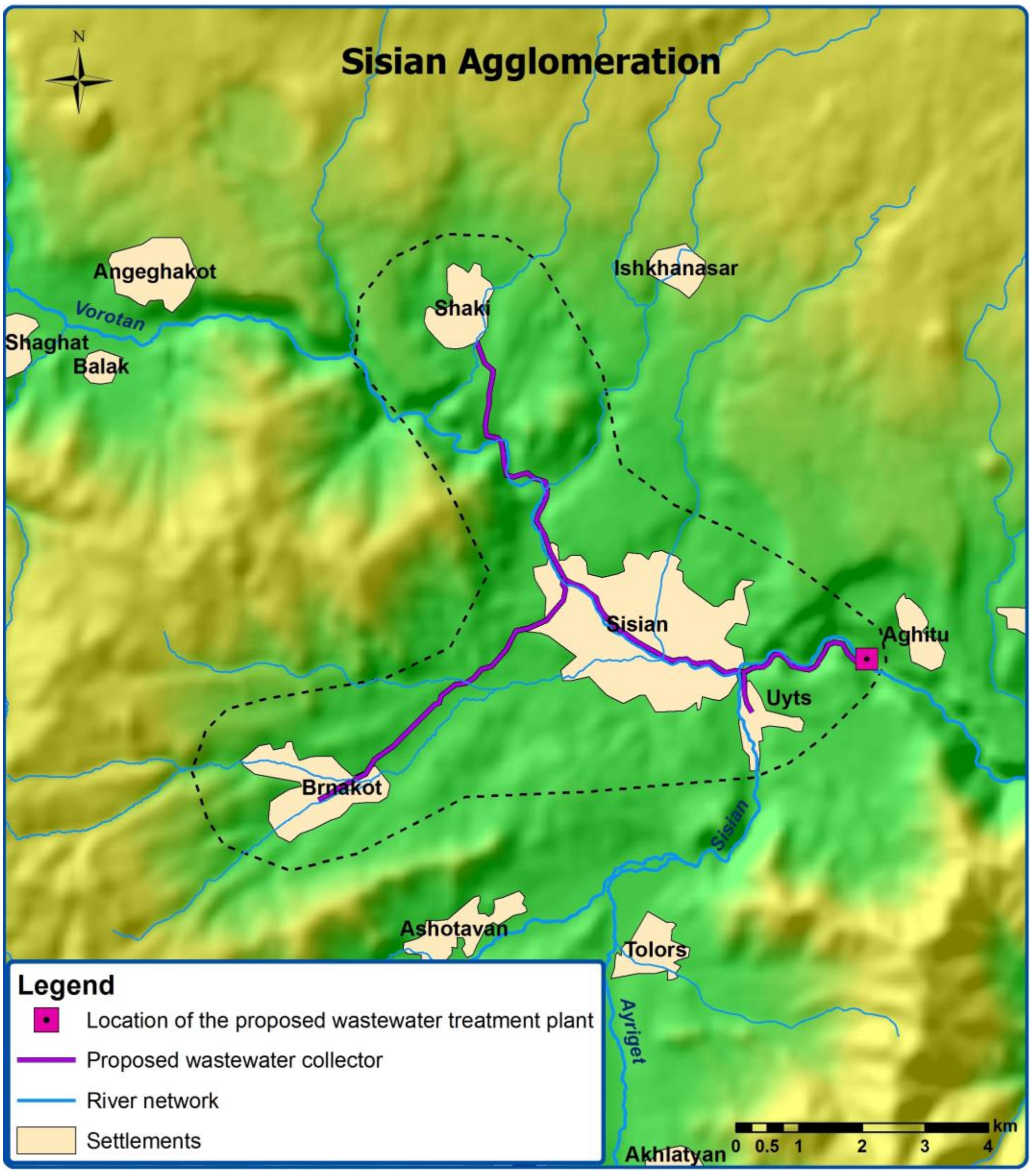


Figure 6.3: Sisian agglomeration and recommended location of WWTP

Source: USAID Clean Energy and Water Program, 2014 (coordinate system: WGS. UTM Zone 38N)

Kapan Agglomeration: The former wastewater treatment plant in the town of Kapan is located 1.7 km south-east of Syunik village. The Kapan WWTP was operational from 1975 to 1990. It was envisaged for wastewater treatment of the town of Kapan and Syunik village, with 25000 m^3/day capacity. Currently, the WWTP is destroyed and looted. Therefore, communal wastewater of Kapan town is discharged without treatment into the Voghji River. It is proposed to build a new WWTP in the place of the former WWTP (Figure 6.4).

Kajaran Agglomeration: Previously operational WWTP was constructed by the Kajaran Copper-Molybdenum Combine and had been operational since 1959. The plant capacity was 4000 m^3/day. As a result of failure to conduct renovation and reconstruction works over the last decades, the treatment facilities and technological equipment had been destroyed and broken. Currently the plant is not operational and wastewater is discharged without treatment into the Voghji River. It is recommended to build a new WWTP in the Voghji River Gorge, 0.1 km downstream the Lernadzor village (Figure 6.5).

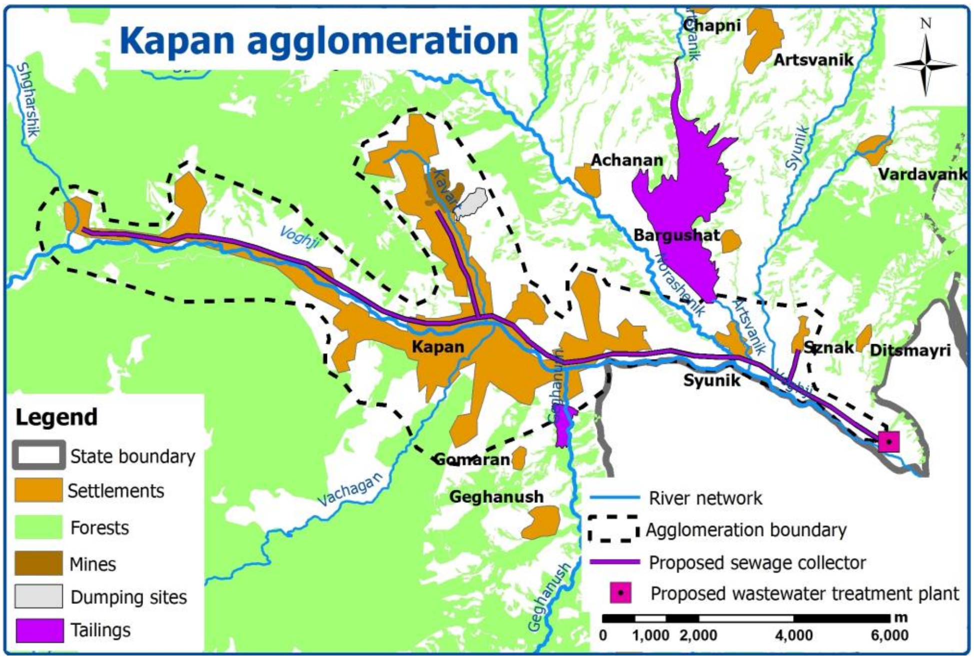


Figure 6.4: Kapan agglomeration and recommended location for WWTP

Source: USAID Clean Energy and Water Program, 2014 (coordinate system WGS. UTM Zone 38N)

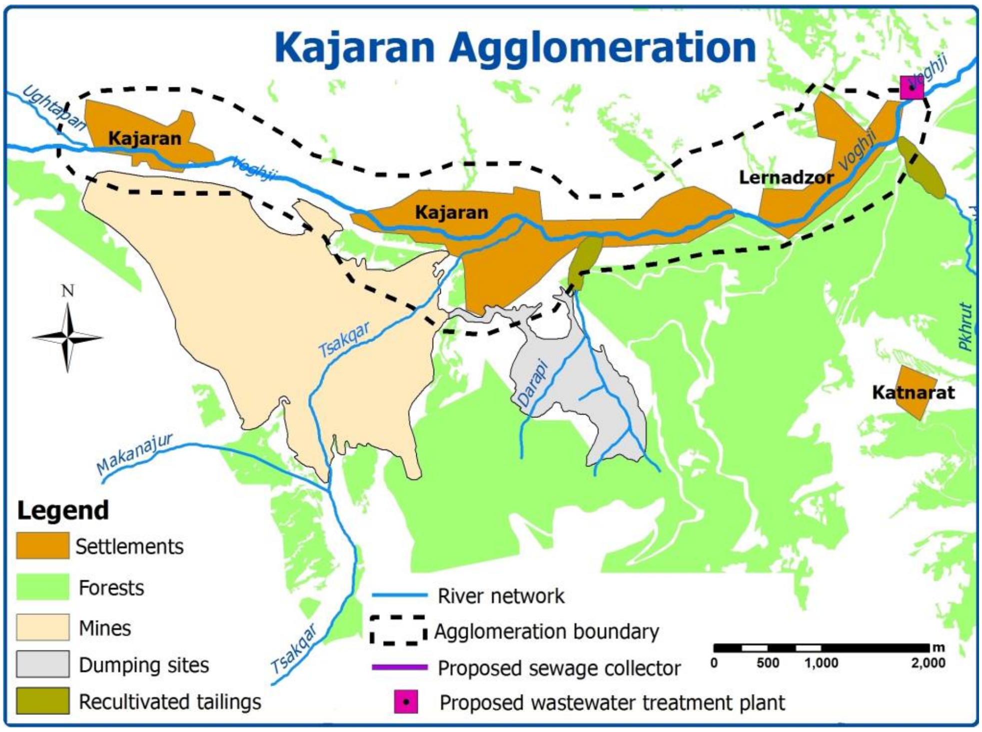


Figure 6.5: Kajaran agglomeration and recommended location for WWTP

Source: USAID Clean Energy and Water Program, 2014 (coordinate system WGS. UTM Zone 38N)

Meghri agglomeration: There has never been a WWTP in Meghri before. The communal wastewater has been discharged into the Meghriget River without treatment. It is recommended to build a new WWTP in the section of Meghriget River located 1 km downstream the town of Meghri (Figure 6.6).

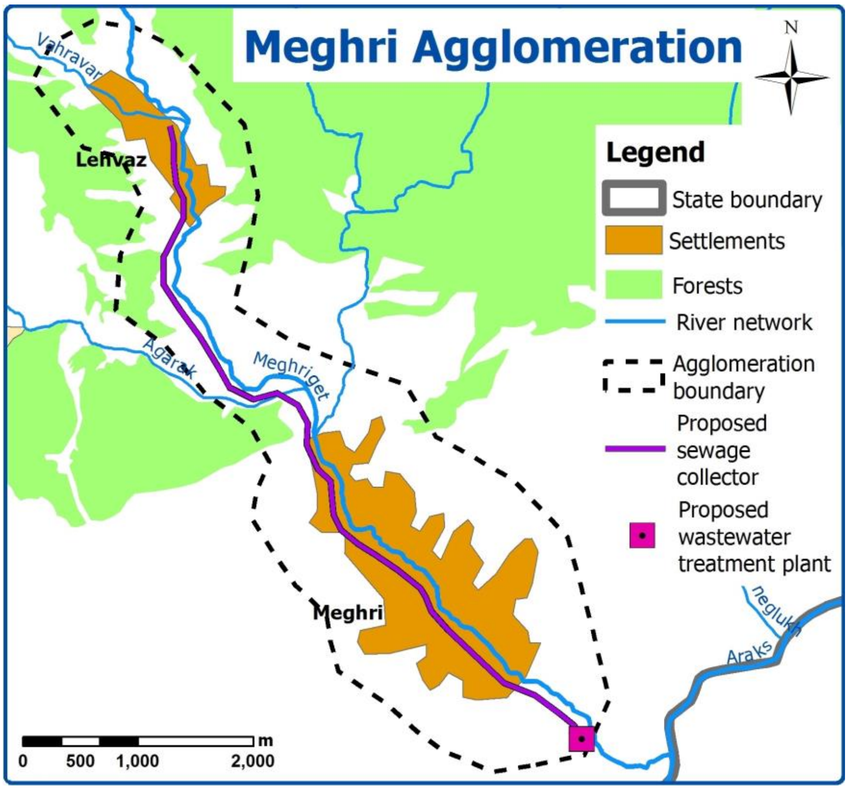


Figure 6.6: Meghri agglomeration and recommended location for WWTP

Source: USAID Clean Energy and Water Program, 2014 (coordinate system WGS. UTM Zone 38N)

Agarak agglomeration: There has never been a WWTP in Agarak before, and wastewater has been discharged into the Karchevan River without treatment. It is recommended to build a new WWTP 1.2 km downstream the town of Agarak (Figure 6.7).

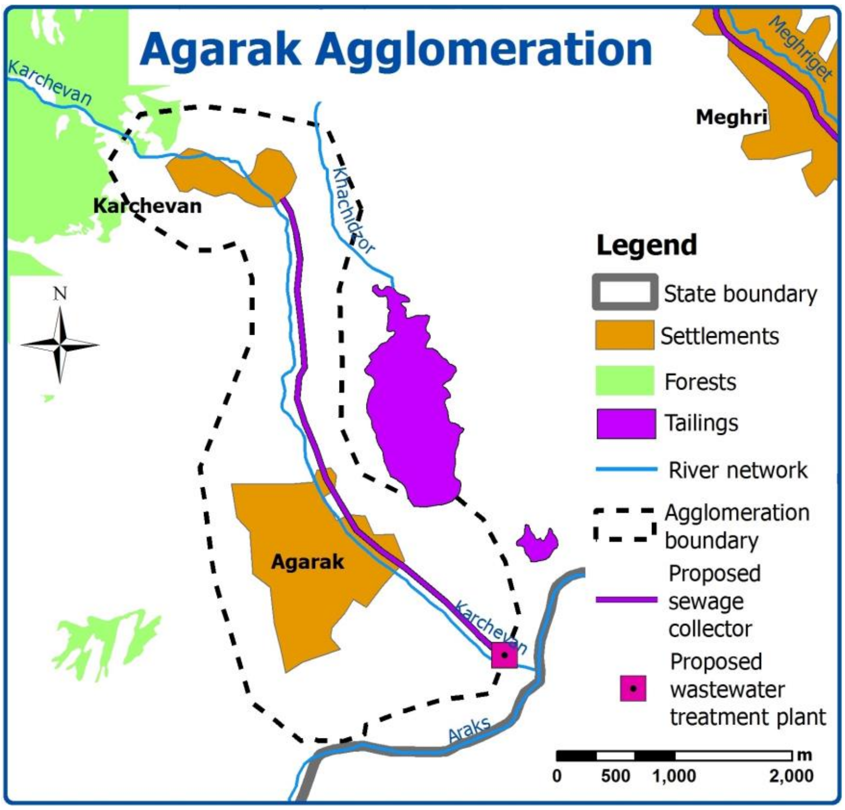


Figure 6.7: Agarak agglomeration and recommended location for WWTP

Source: USAID Clean Energy and Water Program, 2014 (coordinate system WGS. UTM Zone 38N)

6.3.2. Food Industry in Agglomerations

To consider the quantity of BOD_5 discharged from food industry while determining the WWTP capacity, BOD_5 amount (in population equivalent (p.e.)) is calculated in the wastewater discharged from enterprises, as defined in the water use permits.

Goris Agglomeration: In the town of Goris, there are bread and dairy productions. BOD_5 discharged from the Goris Bread Factory is estimated to equal to 100 p.e. There is no data on water use and wastewater removal by the dairy production. For Elola Dairy Factory, the maximum volume of wastewater equaling to 3000 m^3/year was considered based on the maximum designed capacity of the factory. Average amount of BOD_5 discharged from dairy production is estimated to be 1200 kg/m^3, estimate discharge of BOD_5 is estimated at 3600 kg/year or 160 p.e.

Thus, the quantity of wastewater discharged from food industry in Goris agglomeration is equivalent to 260 p.e.

Sisian Agglomeration: Bread and dairy productions are operational in the town of Sisian. BOD_5 quantity discharged from bread factory is estimated at about 100 p.e. BOD_5 amount discharged from Sis-Alp Dairy Factory is estimated at 40 p.e.

Thus, the volume of wastewater discharged from food industry in Goris agglomeration is about 140 p.e.

Kapan Agglomeration: Kapan Bread factory, Vordi Spartak pasta production and bakery, Marila meat and dairy production, Vamax dairy and A. Ohanjanyan meat and dairy productions are operating in the Kapan agglomeration. BOD_5 quantity discharged from Kapan Bread Factory, Vordi Spartak pasta production and bakery is estimated to be 200 p.e. (100 p.e. each).

The industrial wastewater volume discharged from A. Ohanjanyan meat production factory, based on its maximum design capacity, is estimated at 8 894 m^3/year. The average BOD_5 amount discharged from meat food production is estimated at 1500 kg/m^3 by calculated value. By comparing values of wastewater discharged and BOD_5 quantity, the BOD_5 discharged is estimated at 600 p.e. for A. Ohanjanyan meat production factory, 600 p.e. for Marila Meat Product Company, and 160 p.e. for Vamax dairy factory.
Thus, the quantity of wastewater discharged from food industry in Kapa agglomeration is equivalent to 1560 p.e.

Kajaran Agglomeration: At Kajaran town only bread production is relatively large, while other types of food production are very small or absent. BOD_5 discharged from the Kajaran bread factory is estimated at 100 p.e.

Thus, the quantity of wastewater discharge from food industry equals to 240 PE in Meghri agglomeration.

Meghri Agglomeration: BOD_5 quantity discharged from the Meghri bread factory in Meghriget basin is estimated to be 100 p.e. Considering that annual production of Meghri cannery is 200-300 tons, the quantity of industrial wastewater discharge is estimated at 2036 m^3/year. The average BOD_5 load from production is estimated at 1500 kg/m^3. The ratio of the values of wastewater discharge and BOD_5 load shows that the estimated BOD_5 discharge equals to140 p.e.

Thus, the quantity of wastewater discharge from food industry equals to 240 p.e. in Meghri agglomeration.

Agarak Agglomeration: There are small production enterprises in the town of Agarak. Volumes of wastewater discharge are rather small and not considered as being significant. Only the quantity of BOD_5 discharge from Agarak bread factory is considered to be significant, being estimated at 100 p.e.

Thus, the quantity of wastewater discharge from food industry in Agarak agglomeration equals to 100 p.e.

6.3.3. Other Industrial Enterprises in Agglomerations

Non-food industrial enterprises in the Southern BMA are generally small. Several gas stations, car washing and service facilities are operational; limestone production, woodwork, car spare parts production and fixing are typical in the Voghji River Basin. Water use and wastewater discharge by these entities is in small volumes, and estimated values of discharged BOD_5 in p.e. equivalent are quite small and insignificant for the agglomerations. However, car wash services, which are supplied with water by the Armenian Water Supply Company, discharge wastewater to the adjacent water resource instead of the sewage system, as it is required by the environmental expertise documentation issued to the car washing entities. Due to a lack of monitoring data, it is impossible to assess level of pollution of waters with detergents. It is recommended to improve supervision and enforcement of conditions defined for the car wash services, as well as to include detergents control in the new monitoring program.

Of non-food industry, on mining industry is developed.

Large mining enterprises operating in the Voghji River Basin are Dundee Precious Metals and Zangezur Copper-Molybdenum Combine CJSCs. These mining enterprises carry out two types of wastewater removal: communal and industrial. The sewerage system of the enterprises is connected to the sewerage network of the towns of Kapan and Kajaran. Therefore, removed communal wastewater is accounted in the Kapan and Karajan agglomerations.

Dundee Precious Metals Company CJSC annually discharges about 184000 m^3 of wastewater, which is equivalent to 151 p.e., and that for Zangezur Copper-Molybdenum Combine CJSC totals 66 thousand m^3 per year and is equivalent to 54 residents. In addition, about 8000 m3 of wastewater is annually discharged by the Zangezur Copper-Molybdenum Combine CJSC into the to Kajaran town sewerage system, which is equivalent to 7 p.e.

In general, the volume of wastewater removed from other industries in the Kapan and Kajaran agglomerations correspond respectively to 205 p.e. and 7 p.e. There are no other enterprises in the rest of agglomerations.

6.3.4. Type and Capacity of WWTPs in Agglomerations

Based on the cumulative values of BOD_5 loads (the p.e. equivalent) from Goris, Sisian, Kapan, Kajaran, Meghri and Agarak agglomerations, as well as food and non-food industries, the type of WWTP for agglomerations was assessed in accordance with the EU Urban Waste Water Treatment Directive (91/271/EEC) (Table 6.3).

Table 6.3. Recalculated increase of BOD_5 concentration in the agglomerations of the Southern BMA

Agglomeration	*Population*	*Population equivalent of BOD_5 load from food and non-food industry*	*Total p.e.*	*Type of WWTP*
Goris	28578	260	28838 (>10000)	Primary and secondary treatment
Sisian	20789	140	20929 (>10000)	Primary and secondary treatment
Kapan	44627	1765	46392(>10000)	Primary and secondary treatment
Kajaran	8295	107	8402 (2000–10000)	Primary treatment
Meghri	5223	240	5463 (2000–10000)	Primary treatment
Agarak	5000	100	5100 (2000–10000)	Primary treatment

According to the aforementioned, the total quantity of BOD_5 discharged from Goris town is equivalent to 28838 p.e. Hence, it is required to apply both primary and secondary treatment in Goris WWTP having more than 10000 “population equivalent”. Primary treatment envisages physical and/or chemical treatment of urban wastewater, ensuring sedimentation of suspended solids or other processes, as a result of which after the treatment process the BOD_5 value will be reduced at least by 20%, as compared to non-treated wastewater. At the same time, quantity of suspended solids will reduce by 50%. Secondary treatment includes biological treatment of wastewater, which is accompanied by secondary sedimentation (or other processes), providing for compliance of the treated water with acceptable norms.

Based on the ecological status of the Gorisget River, BOD_5 (p.e. equivalent value) discharged and the development trends in the region, it is recommended to build a WWTP for Gorist agglomeration with 15.000 m^3/day design capacity and a 14 km long new sewage collector.

The total quantity of BOD_5 discharged from the town of Sisian is equivalent to 20929 p.e., which exceeds the 10000 p.e. threshold and requires application of both primary (mechanical) and secondary (biological) treatment in the Sisian WWTP. Based on the ecological status of the Vorotan River, p.e. equivalent value of BOD_5 discharged and the development trends in the region, it is recommended to build a WWTP with 10000 m^3/day design capacity and a 12 km long new sewage collector for the Sisian agglomeration.

The total quantity of BOD_5 discharged from the town of Kapan is equivalent 46392 p.e., which also exceeds the 10000 p.e. threshold, and requires application of both primary (mechanical) and secondary (biological) treatment in Kapan WWTP. Based on the ecological status of the Voghji River, p.e. equivalent value of BOD_5 discharged and development trends in the region, it is recommended to build a WWTP with 25.000 m^3/day designed capacity and a 19 km long new sewage collector for Kapan Agglomeration.

Based on expert judgment, the total BOD_5 load from Kajaran wastewater is estimated at 8402 p.e. It is recommended to apply only primary (mechanical) treatment for Kajaran WWTP, which will ensure BOD_5 reduction in wastewater according to the norms applied. Taking into account the p.e. equivalent value of BOD_5 discharged in the agglomeration, as well as development trends in the region, it is recommended to build a WWTP with 3500 m^3/day designed capacity and a 8.3 km long new collector in Kajaran Agglomeration.

The total BOD_5 quantity discharged from the town of Meghri is equivalent to 5463 p.e. As it does not exceed the 10000 p.e. threshold, it is required to apply only physical (mechanical) treatment in Meghri WWTP. Based on the Meghriget ecological status, p.e. equivalent value of BOD_5 discharged, as well as development trends in the region, it is recommended to build a WWTP with 2.000 m^3/day designed capacity and a 7.2 km long new sewage collector for the Meghri Agglomeration.

The total BOD_5 quantity discharged from the town of Agarak is equivalent to 5100 p.e., hence, it is envisaged to apply only physical (mechanical) treatment for Agarak WWTP. It will ensure reduction of BOD_5 in wastewater in accordance to the applicable norms. Taking into account the p.e. equivalent value of BOD_5 discharged in the agglomeration, as well as the development trends in the region, it is recommended to build a WWTP with 2.000 m^3/day designed capacity and a 4.7 km long new sewage collector for the Agarak Agglomeration.

6.3.5. Wastewater of Settlements Not Incorporated in Agglomerations

For the settlements that are not included in the agglomerations, including 54 in the Vorotan, 26 in the Voghji and 9 in the Meghriget River Basins, it is recommended to conduct feasibility studies to identify the possibility and viability of implementing alternative measures for treatment of communal wastewater (septic wells, biological ponds, local small-scale primary (chemical/mechanical) treatment systems, etc).

Based on preliminary expert judgment, it is proposed to build biological ponds (including collection network) for treatment of communal wastewater in 5 settlements located in the northern part of the Vorotan River basin - Tsghuk, Gorhayk, Dastakert, Sarnakunq and Spandaryan.

According to the requirements of the EU Urban Wastewater Treatment Directive, it is not required to have WWTP in communities with small population (500 p.e.). Population of the rest of the settlements that re not included in agglomeration proposed in the Voghji and Meghriget River Basins does not exceed that number, except for Artsvanik village in Voghji River basin. It is recommended to remove the communal wastewater of Artsvanik village to Artsvanik tailing pond, as no other appropriate alternative is available in that area. As there is a possibility of removing communal wastewater directly to the tailing pond, and to natural any water resource, construction of a WWTP in this area is considered as unnecessary.

6.3.6. Agricultural Crops

In order to reduce the impact of agricultural activities on the environment, it is necessary to make rational use of natural resources (land. water. etc.) through introduction of good agricultural practices (GAP) and establishment of effective farms.

It is recommended to introduce GAP in the Southern BMA with implementation of the following measures:

1. Identification of agricultural activities that are having impact on surface water and groundwater (pressures from agricultural activities);
2. Identification of GAP to improve farms and to bring the impact of agriculture on water bodies to the minimum;
3. Conducting training for farmers on GAP by presenting the experience and the results of implemented pilot programs;
4. Raising awareness of farmers. the public and other stakeholders about GAP;
5. Introducing/implementing effective agro-technical measures for maintenance of soil humidity and reduction of evaporation volumes in the context of forecasted climate change, including:
    - Substitution of crops with high water demand with drought tolerant and resistant species;
    - Conducting crops rotation;
    - Using organic mulch and bio humus;
    - Agroforestry;
    - Restoration of forested areas.
6. Improvement of irrigation systems by introduction of modern water saving technologies (drip irrigations. sprinkling, energy-efficient systems) and reduction of flow losses.
7. In order to mitigate long-term climate change risks and to cover the projected water deficit. it is recommended to build of the following reservoirs in the Southern BMA: in Vorotan River Basin - Mukhuturyan Reservoir, with about 2.5 MM m^3 designed storage capacity, in the Voghji River Basin – Norashenik Reservoir with about 17 MM m^3 designed storage capacity, and in the Meghriget River Basin – Lichk Reservoir with about 3.8 MM m^3 designed capacity. This will allow for storing water and providing irrigation water to arable lands low-flow seasons.

It is recommended to implement the above-stated measures in the following pilot communities of the Southern BMA:

- 5 villages in the Vorotan River Basin – Ashotavan, Darbas, Khndzoresk, Shinuhayri and Halidzor;
- 4 villages in the Voghji River Basin – Artsvanik, Norashenik, Achanan and Shikahogh;
- 3 villages in the Meghriget River Basin – Alvank, Vardanidzor and Lichk.

6.3.7. Livestock Breeding

Manure and return flows from slaughter houses, inter alia, pose significant pressures on water resources. To mitigate the impact of manure on the quality of water resources, it is recommended to develop a manure collection system from livestock farms, which will include accumulation of manure in appropriate pits and their further use for fertilizing agricultural lands.

Such manure management system will include the following components:

1) Manure accumulation sites/facilities;
2) Manure distribution equipment;
3) Areas for use of manure (crop fields).

To mitigate the impact of return flows of the livestock farm slaughter houses on the quality of water resources, it is recommended to provide collector and treatment systems for the return flows for securing treatment of the return flows before discharging into adjacent river.

Such measures will enable to reduce significant pressures on the Southern BMA water bodies and to increase productivity of agricultural crops.

It is recommended to implement the following measures in 5 pilot villages in the Vorotan River Basin (Gorhayk, Khoznavar, Sisian, Shenatagh and Harzhis), 6 pilot villages in the Voghji River Basin (Lernadzor, Artsvanik, Kapan, Syunik, Geghi and Verin Khotanan) and 4 pilot villages in the Meghriget River Basin (Meghri, Vardanidzor, Shvanidzor and Tashtun): to develop a guidebook of good livestock management practices, deliver appropriate training and capacity building to farmers and implement good livestock management practices by gradual introduction of the advanced international practices in the Southern BMA.

6.3.8. Solid Wastes

Landfills

The pressure of solid waste in the Southern BMA is connected with operational solid waste landfills. The following municipal waste landfills are operated in the towns of the Southern BMA: Sisian landfill (2 ha), Goris landfill (10 ha), Kapan landfill (13 ha), Agarak landfill (3 ha) and Meghri landfill (2 ha). These are in poor condition, and sanitary norms are not maintained: there is no fencing, and required disinfection in place. Household waste of Kajaran town is disposed at the waste dumpsite of Zangezur Copper-Molybdenum Combine CJSC, which is covered by the company with soil layer. Taking the above-stated into account, there is no need to take additional measures for the waste landfill in the Kajaran town.

Effective measures to limit the movement and dissemination of solid wastes and the pollution of the surrounding environment in the Southern BMA include:

(a) Building a small waste processing/recycling plant, which is costly, or
(b) Replacing the above presented operational landfills with sanitary waste landfills, which is more realistic and less costly.

It is proposed to conduct conservation of currently operational landfills of the Sisian, Goris, Kapan, Agarak and Meghri towns and replace these with sanitary landfills. It is necessary to cover the currently operation landfills with a clay layer (up to 20 cm layer), sand/soil layer (up to 30 cm thick) and with vegetation.

In order to establish sanitary landfills in the areas currently allocated for municipal landfills of the towns, it is necessary to provide for the following conditions:

- *Complete or partial hydrogeological insulation*: if the landfill cannot be located on such soil which, under natural conditions, secures wastewater insulation, some additional special materials should be applied, which will reduce wastewater penetration into soil layer and pollution of groundwater and adjacent soils. Should soil or synthetic insulation layer be provided without wastewater collection

system, all wastewater will eventually reach the surrounding environment. Wastewater collection and treatment should be highlighted as a core requirement.
- *Formal engineering preparations*: projects should take into account the results of geological and hydrogeological investigations for the site. In addition, municipal waste disposal plan and final site restoration plan should be developed.
- *Permanent control*: Trained staff should be present in the sanitary landfill to control everyday activity of site preparation and operation, waste disposal, as well as operation and maintenance of the sanitary landfill.
- *Planned waste disposal and covering*: waste should be placed in layers and compacted. Small work site area, which is covered with soil layer on a daily basis, limits the spread of waste and accessibility for pests and parasites.

Thus, it is recommended to convert the existing waste landfills in the Southern BMA into sanitary landfills.

In addition, it is recommended to implement, where possible, measures aimed at waste reduction, reuse (for example reusable bottles) and processing.

In settlements of the Southern BMA where riverbeds are polluted with solid wastes that pose significant pressure on the quality of waters, it is recommended to place waste bins in appropriate locations and to conduct effective waste removal and disposal. It is also proposed to organize cleaning activities of littered river beds.

6.3.9. Mining

- Wastewater discharge

Wastewater discharge from mining is taking place mainly in the Voghji and Meghriget River Basins of the Southern BMA. Mining industry is one of primary sources of pollution of water resources and posing significant pressure on the resources. To improve the quality of wastewater removed from mining industry, it is recommended to introduce new wastewater treatment technologies. Zangezur Copper-Molybdenum Combine discharges directly into the Voghji River 473000 m^3 of untreated wastewater annually; Dundee Precious Metals Company CJSC discharges into the Norashenik River 208140 m^3 of wastewater annually; Agarak Copper-Molybdenum Combine discharges into the Karchevan River 1.5 MM m^3 of wastewater annually: Sipan-1 Company that operates small underground gold mines of Lichkvaz-Tey and Terterasar discharges directly into the Meghriget River 107000 m^3 of wastewater annually. Installation of the treatment technologies will allow reducing concentrations of pollutants in the wastewater to the levels defined by the WUPs.

- Waste Dumps

Mining waste dumps that exist in the Southern BMA belong to Zangezur Copper-Molybdenum Combine, Dundee Precious Metals Company, Agarak Copper-Molybdenum Combine and Sagamar CJSCs in the Voghji and Meghriget River Basins. These are open waste dumps and have direct impact on water resources.

Surface runoff of Kajaran mine waste dumps discharge into the Voghji River near the town of Kajaran. Surface runoff from the Kapan mine waste dumps discharge into the Voghji River near the town of Kapan via Kavart tributary and pollute not only the river, but also the central part of the Kapan town. Surface runoff from the Hanqasar dump sites discharges into the Ajabaj and Geghi Rivers.

Surface runoff from the slopes of the Agarak mine dump sites which contains heavy metals and solid substances run into the Karchevan and Agarak Rivers, and waste dumps of the Lichkvaz-Tey polymetallic gold deposit are directly located in the Meghriget River floodplain.

It is proposed to reclaim the slopes of the above described mining waste dumps by reinforcing those with soil layer and providing vegetation cover.

According to expert assessment, surface of the areas that needs to be reclaimed are as follows: Zangezur Copper-Molybdenum Combine Company - 23 ha, Dundee Precious Metals Company CJSC - 14 ha, Agarak Copper-Molybdenum Combine company – 22 ha, and Lichkvaz-Tey polymetallic gold deposit – 1.2 ha.

- Tailing ponds

It is proposed to implement the following measures in the currently operational 6 tailing ponds in the Voghji River Basin (Artsvanik, Geghanush and Geghi) and Meghriget River Basin (Darazami, Hovit 1 and Hovit 2), and 3 reclaimed tailing ponds in the Vorotan River Basin (Dastakert) and Voghji River Basin (Voghji and Pkhrut) of the Southern BMA:

- Covering the eroded areas of the reclaimed Voghji, Pkhrut and Dastakert tailing ponds, comprising 18, 3 and 2.5 ha respectively, with a clay then soil layers and providing for vegetation cover;
- The Kishkosht River that flows through the area of non-operational Dastakert tailing pond, mixes with wastewater and wastes of the tailing pond and polluting the Ayriget River. It is recommended to divert the flow of about 250 m long section of the Kishkosht River (which flows through the eroded areas of the Dastakert tailing pond) carbon fiber pipe with 1400 mm in diameter.
- Conducting a feasibility study for bringing the settling/sedimentation tanks of the Ler-Ex company with 50000 m^3 and 35000 m^3 volume in compliance with the requirements for the tailing ponds (operation of the company is temporarily ceased as a consequence of existing environmental problems);
- Maintenance of technical rules to operate Artsvanik, Geghanush, Darazami, Hovit 1 and Hovit 2 tailing ponds for the purpose of protection of water resources and the surrounding environment in the Southern BMA;
- Rehabilitation of damaged section of the mining tails pipeline of the Artsvanik tailing dam (total length is 150 linear meters) that is a source of pollution of waters of Geghi and Norashenik Rivers. Length of the damaged pipeline in the Geghi River basin section is 90 linear meters, and in the Norashenik River Basin section – 60 linear meters);
- Rehabilitation of the 70 m long damaged section the of pipeline in the Karchevan River Basin that coveys tailings to Hovit 1 and Hovit 2 tailing dams;
- Installation of a small industrial water treatment plant on the tunnel reaching to Achanan River Basin from Artsvanik tailing dam.

6.3.10. Hydropower generation

The following measures are proposed for reducing pressures on ecological flow of the Tsghuk, Shaqi, Voghji and Meghriget Rivers as a result of operation of the SHPPs in the Southern BMA:

- Installation of water meters at the water abstraction/intake point of each SHPP;
- Securing fish passes.

It is necessary to conduct environmental impact assessment for separate technical measures proposed in this section, following the requirements of the RA legislation.

6.4. New Program for Water Resources Monitoring Recommended for Achievement of Defined Environmental Objectives

The new monitoring program recommended for the Southern BMA is based on data collected during characterization of the basin management area, as well as results of pressures and impacts analysis, delineation of water bodies at risk.

The main objective of the new monitoring program is to provide data for water resources ecological status assessment. It was developed by taking into account the EU WFD principles and includes operational, surveillance and investigative, as well as two additional types of monitoring – reference and pollutants transfer.

Operational monitoring is defined for such water bodies, which have been delineated as water bodies at risk, as a result of significant anthropogenic pressures. Goral of this type of monitoring is to assess any change in the status of the water body at risk over a period of time.

Surveillance monitoring is defined for such water bodies not at risk that are permanently under some small impact which is considered as insignificant. The objective of surveillance monitoring is to receive satisfactory information on the impact of human activity on water bodies not at risk with the catchment.

Investigative monitoring is defined for such water bodies not at risk, where:

- The reasons for any environmental problem are unknown;
- Surveillance monitoring is not sufficient for receiving necessary information on anthropogenic impact, and where such water body has not yet been confirmed as a water body at risk;
- It is necessary to identify the scope and consequences of pollution resulting from accidents.

The monitoring of pollutants transfer (an additional type of monitoring) has been approved for transboundary water bodies in the Southern BMA, and is defined in the regime of the operational monitoring.

Reference monitoring type is defined for such water bodies, which are free of any anthropogenic impact or where such impact is insignificant. It specifies the natural status of the given river.

The number of monitoring points, selection of parameters and sampling frequency for the Southern BMA are reduced to the minimum with the view of not exceeding, to the extent possible, the current expenditures for implementation of surface and ground water resources monitoring and maintaining the available data sets. The new monitoring program includes also currently operational 19 sampling points for surface water quality monitoring, 10 observation points for hydrological monitoring and 9 ground water monitoring points.

The new monitoring program could be revised in the first six-year management planning cycle, if there is a change in the status of water bodies.

6.4.1. Overview of the New Surface Water Monitoring Program

The new surface water resources monitoring program in the Southern BMA envisages 44 hydrological observation points, including 22 for operational, 4 for surveillance, 2 for investigative, 6 for pollutants transfer and 10 for reference monitoring. The hydrological observation points are distributed on 19 large and middle size rivers, including 8 rivers in the Vorotan River Basin, 8 - in the Voghji River Basin and 3 rivers in the Meghriget River basin (Table 6.4, Figure 6.8).

Table 6.4. Complete list of surface water monitoring points combined with water body

Number of observation point	Number of the water body	Water resource	Location of the observation point	Altitude. m. s. l.	Monitoring type
			Vorotan River Basin		
1	WB-01	Vorotan	1.5 km upstream the Gorhayk village, to the north-east	2100	Reference
2	WB-07	Vorotan	7 km downstream the Spandaryan reservoir	1823	Surveillance
3	WB -09	Vorotan	1 km upstream the Sisian town	1610	Surveillance
4	WBR-01	Vorotan	2 km downstream the Sisian town	1510	Operational
5	WBR-02	Vorotan	Near the Vorotan village	1387	Operational
6	WBR-03	Vorotan	0.6 km downstream the Shamb reservoir	1320	Operational
7	WBR-03	Vorotan	0.5 km downstream the Tatev HPP	730	Pollutants transfer
8	WBR-04	Tsghuk	At the river mouth	2100	Operational

Number of observation point	Number of the water body	Water resource	Location of the observation point	Altitude. m. s. l.	Monitoring type
9a	WB -11	Sisian	In the Arevis village	1880	Reference *(only hydrology)*
9b	WB -11	Sisian	0.5 km upstream the Arevis village	1900	Reference *(only hydrochem.. hydrobiol.)*
10	WBR-06	Sisian	0.5 km upstream the Ashotavan village, to the south-east	1670	Operational
11	WBR-07	Sisian	At the river mouth, near the Uyts settlement	1665	Operational
12	WB -13	Ayriget	0.7 km upstream of confluenceof Kishkosht tributary	1845	Reference
13	WB -15	Ayriget	At the river mouth	1660	Surveillance
14	WBR-08	Kishkosht	At the river mouth	1840	Operational
15	WB -16	Loradzor	0.5 km downstream the Ltsen village, to the north-west	1360	Investigative
16	WB -18	Gorisget	3 km above t. Goris p	1860	Reference
17a	WBR-09	Gorisget	In t. Goris	1430	Operational (only hydrology)
17b	WBR-10	Gorisget	1.5 km upstream the Goris tpwn	1080	Operational *(only hydrochem.. hydrobiol.)*
18	WB -21	Qashuni	Near the Davit Bek village	1040	Pollutants transfer
		Voghji River Basin			
19	WB -24	Voghji	1.7 km upstream the Kajaran town	1970	Reference
20a	WBR-11	Voghji	In the Kajaran town	1750	Operational (only hydrology)
20b	WBR-12	Voghji	1.8 km downstream the Kajaran town	1615	Operational *(only hydrochem.. hydrobiol.)*
21	WBR-13	Voghji	1 km upstream the confluence of Geghi River, downstream the Musalam village	1300	Operational
22	WBR-14	Voghji	0.8 km upstream the Kapan town	940	Operational
23a	WBR-15	Voghji	In the Kapan town	760	Operational *(only hydrology)*
23b	WBR-15	Voghji	Near the Kapan airport, upstream the discharge of Norashenik River	685	Operational *(only hydrochem.. hydrobiol.)*
24	WBR-16	Voghji	6.8 km downstream the Kapan town	655	Pollutants transfer
25	WBR-17	Tsakqar	At the river mouth	1800	Operational
26	WBR-18	Darapi	At the river mouth	1760	Operational
27	WB -28	Geghi	1 km upstream the Ajabaj village	2045	Reference
28	WBR-19	Geghi	0.5 km downstream the Ajabaj village	1900	Investigative
29	WB -30	Geghi	In the Geghi village	1546	Surveillance
30	WB -32	Geghi	At the river mouth	1267	Operational
31	WBR-20	Kavart	At the river mouth, in Kapan town	800	Operational
32	WBR-21	Vachagan	At the river mouth, in Kapan town	775	Operational
33	WB -36	Geghanush	1 km upstream the Geghanush village, to the west	946	Reference
34	WBR-22	Geghanush	At the river mouth	754	Operational
35	WB -37	Norashenik	1 km upstream the Vanik village, to the north-west	1173	Reference
36	WBR-23	Norashenik	At the river mouth, near the Kapan airport	693	Operational
		Meghriget River Basin			
37	WB -42	Tsav	6.5 km upstream the Tsav village	1640	Reference
38	WB -42	Tsav	At the river mouth, near the Nerqin Hand village	685	Pollutants transfer
39	WB -43	Meghriget	250 m upstream the Lichk village, to the west	1825	Reference
40	WBR-24	Meghriget	1 km upstream the Tkhkut village	1235	Operational
41	WBR-25	Meghriget	Near the Vardanidzor village	1040	Operational
42	WBR-26	Meghriget	0.5 km upstream the Meghri town	710	Operational
43	WBR-27	Meghriget	At the river mouth	514	Pollutants transfer
44	WBR-28 WBR-29	Karchevan	At the river mouth	546	Pollutants transfer

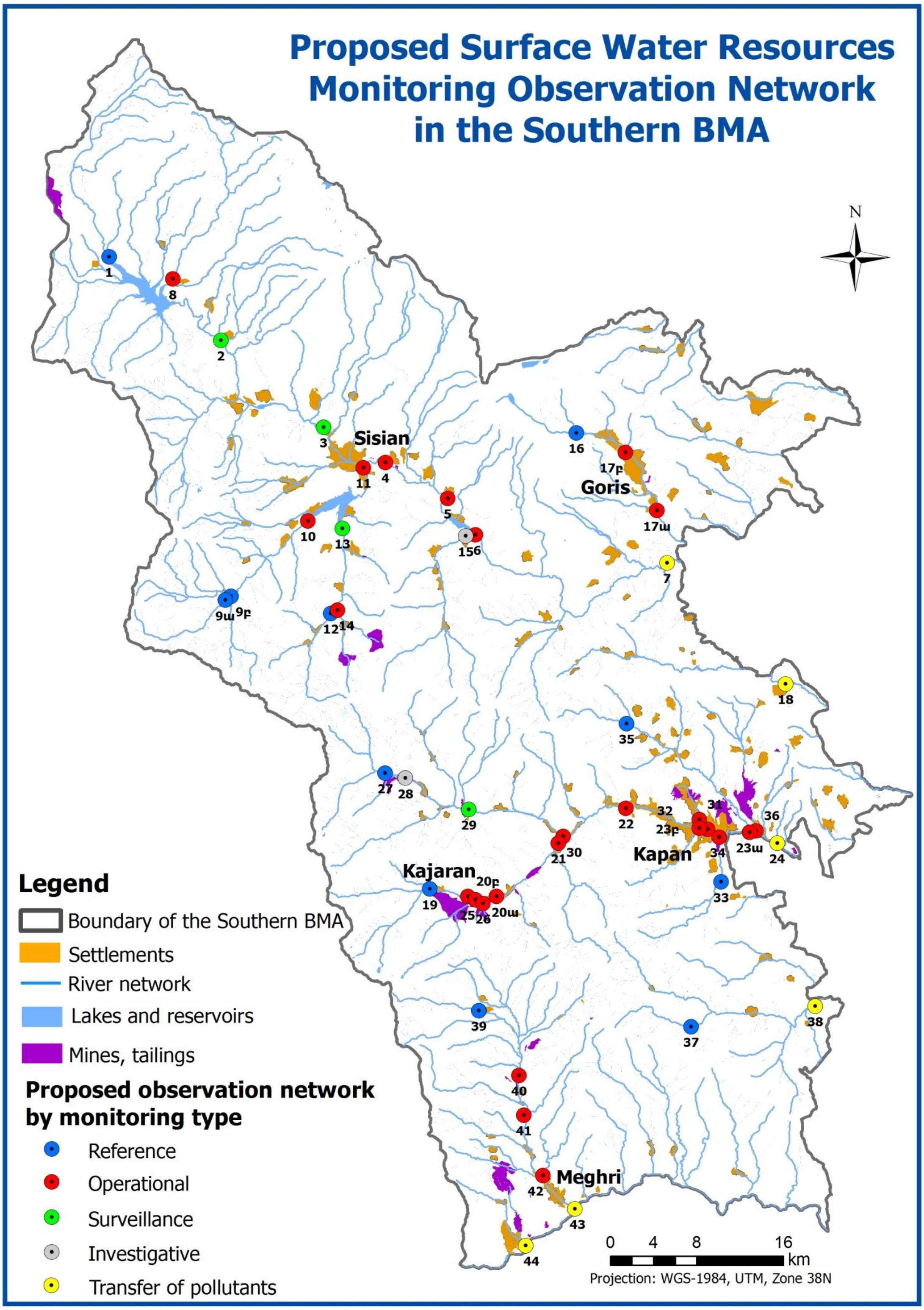


Figure 6.8. Recommended network for surface water resources monitoring in the Southern BMA

Source: USAID Clean Energy and Water Program, 2014

Selection of the observation points is based on their accessibility and the extent to which the given observation point(s) is representational for the water body under examination, in terms of pressures and hydromorphology. One observation point is compulsory selected for each water body at risk. There are 2 water bodies at risk - WBR-05 (Shaqi River) and WBR-30 (Khachidzor River), where no observation points were envisioned. Visual expert assessment of these river stretches is proposed to be implemented throughout the first 6- year cycle of the basin management planning.

The proposed monitoring program includes hydrochemical, hydrobiological and hydromorphological monitoring of surface waters. The list of water quality parameters to be monitored is prepared in compliance with the EU WFD requirements and the RA Government Decree No. 75-N (Annex F). The list of parameters defined for surface water monitoring contains 101 hydrochemical (WFD primary pollutants – 42, specific pollutants – 7 and other chemical parameters – 52) and 1 hydrobiological parameter.

Hydrobiological monitoring is the most important component of the comprehensive program for surface waters monitoring. According to the WFD requirements, there are five hydrobiological quality elements (macroinvertebrates, phytobenthos, phytoplankton, macrophytes and fishes) which characterize the ecological status of water resources. These are measured simultaneously with hydromorphological and hydrochemical parameters.

It is proposed to monitor macroinvertebrates only from the hydrobiological elements in the fi first six-year management planning cycle in the Southern BMA planning, as the monitoring methods for other elements are currently underdeveloped, and Armenia is still lacking the practice of classifying the monitoring data by status (excellent, good, moderate, poor, bad).

It is envisaged to conduct the sampling of macroinvertebrates in all observation stations, once a year (Table 6.5). It is recommended to conduct sampling during autumn/winter low-flow period, which will facilitate the sampling process. In addition, the anthropogenic impact on water ecosystems is the highest during the low-flow period, and insects' larvae which provide important information for classification are observed at that period.

It is proposed to conduct hydrochemical monitoring in all types of observation points with the frequency defined in Table 6.5.

Table 6.5: Frequency of observations proposed for all types of surface waters monitoring in the Southern BMA

Type of observation point	***Hydrochemical monitoring***	***Hydrobiological monitoring***	***Hydrological monitoring***	***Hydromorphological monitoring***
Red: Operational	12 times a year – mainly for physical and chemical parameters, as well as heavy metals; seasonal – for WFD primary and specific pollutants. Determination of heavy metals in bottom sediments every 2nd year	Once a year – in low-flow period, along with hydrochemical monitoring	12 times a year	Twice a year – in high-flow and low- flow periods, it should overlap with hydrobiological monitoring
Green. Surveillance	6-7 times a year (4 times for WFD primary and specific pollutants), one should overlap with hydrobiological monitoring	Once a year during low-flow period, along with hydrochemical monitoring	6-7 times a year, at the same time as hydrochemical monitoring	Once a year, at the same time as hydrobiological monitoring
Blue. Reference	Seasonal, 4 times a year, one should overlap with hydrobiological monitoring	Once a year, during low-flow, along with hydrochemical monitoring	Seasonal. 4 times a year. simultaneously with hydrochemical monitoring	Once a year. at the same time as hydrobiological monitoring
Light blue. Investigative	Once every 2 years, at the same time as hydrobiological, hydrological and hydromorphological	Once every 2 years during low-flow period, along with hydrochemical monitoring	Once every 2 years (at the same time as biological monitoring)	Once every 2 years (at the same time as biological monitoring)

Type of observation point	Hydrochemical monitoring	Hydrobiological monitoring	Hydrological monitoring	Hydromorphological monitoring
	monitoring			
Yellow. Pollutants transfer	12 times a year – mainly for physical and chemical parameters, as well as heavy metals; seasonal for WFD primary and specific pollutants. Every 2nd year determining heavy metals in bottom sediments	Once a year during low-flow period, along with hydrochemical monitoring	12 times a year	Twice a year during high-flow and low- flow periods , it must overlap with hydrobiological monitoring

According to the list defined under Annex 2 of the RA Government Decree No. 75-N. of 101 hydrochemical parameters characterizing water quality of surface waters only 45-60 parameters are currently being monitored and assessed. Monitoring of the rest of parameters is in the phase of introduction. During the first six-year management planning cycle in the Southern BMA it would be possible to review the list of recommended hydrochemical parameters in parallel to introduction of the methods for determining new parameters.

In parallel to hydrochemical monitoring, it is proposed to monitor heavy metals in bottom sediments in all operational monitoring points every second year during the first six-year management planning cycle, which will provide information for assessing pressures form the mining activities.

The other component of the comprehensive surface waters monitoring is hydrological and hydromorphological monitoring, which provides information on river flow that is necessary in course of analyzing the data received during hydrobiological and hydrochemical monitoring types. In addition, it would be impossible to assess human and natural impacts on water resources without quantitative data.

The best option is conducting flow measurements through direct measurements of river depth, width and water velocity. Currently, water velocity (m/sec) can be used for hydrobiological assessment, while the calculated flow (m^3/sec.) could be used for assessment of hydrochemical monitoring results, calculation of the coefficient of dilution of wastewater discharged upstream the monitoring observation point, as well as the daily and annual pollutants transfer. In addition, morphological conditions of all monitoring points will be assessed for flow measurement.

6.4.2. Overview of the New Groundwater Monitoring Program

The new groundwater monitoring program proposed for the Southern BMA is based on Guidelines for Groundwater Monitoring in the Pilot River Basins of Caucasus Countries report developed within the framework of the EU funded Project on Environmental Protection of International River Basins in 2014, that was submitted to the RA government for approval. It includes quantitative and qualitative groundwater monitoring which is distinguished by operational surveillance and investigative types.

The new network proposed for groundwater monitoring is based on the existing data about hydrogeology of each groundwater body and anthropogenic pressures. The recommended monitoring program is subject to revision during the first six-year cycle of basin management planning based on availability of new data.

In addition to groundwater monitoring 9 points that are currently operational in the Southern BMA, it is proposed to conduct groundwater monitoring in 19 new points, including 14 at the springs, 4 – at boreholes, and 1 at kyahriz (underground channel). Thus, 28 monitoring points are proposed for 15 groundwater bodies identified in the Southern BMA, including 20 points for surveillance and 8 points for investigative monitoring (Table 6.6, Figure 6.9).

Table 6.6: The list of points recommended for groundwater resource monitoring in the Southern BMA

N/N	Code of monitor-ing point	Number	Geographic coordinates		Type of the monitoring point	Location	Type of monitoring	Absolute level, m
			Eastern longitude	Northern latitude				
1	G01-1	529	45° 46' 06.9"	39° 41' 54.3"	spring	v. Gorhayk	surveillance	2070
2	G01-2	537	45° 54' 06.9"	39° 37' 53.1"	spring	v.Spandaryan	surveillance	1995
3	G01-3	532	46° 00' 00.9"	39° 33' 52.5"	group of springs	v. Shaqi	surveillance	1702
4	G01-4	1175	45° 56' 18.4"	39° 34' 23.9"	spring	v. Angeghakot	surveillance	1751
5	G01-5	1322	45° 56' 25.8"	39° 34' 23.2"	spring	v. Angeghakot	surveillance	1714
6	G01-6	1318	45° 56' 31.7"	39° 34' 22.5"	spring	v. Angeghakot	surveillance	1690
7	G01-7	1323	45° 56' 32.9"	39° 34' 20.4"	spring	v. Angeghakot	surveillance	1514
8	G01-8	new	46° 02' 04.1"	39° 31' 01.9"	borehole	t. Sisian	surveillance	1580
9	G01-9	new	45° 56' 01.6"	39° 33' 45.7"	borehole	v. Tolors	surveillance	1685
10	G01-10	new	46° 08' 22.7"	39° 29' 07.8"	borehole	v. Vorotan	investigative	1370
11	G02-1	899	46° 21' 05.8"	39° 30' 36.8"	spring	t. Goris	surveillance	1348
12	G02-2	1399	46° 21' 26.2"	39° 30' 25.6"	group of springs	t. Goris	surveillance	1470
13	G02-3	new	46° 16' 28.2"	39° 32' 15.4"	group of springs	v. Akner	investigative	1900
14	G03-1	new	46° 16' 28.2"	39° 22' 20.1"	spring	t. Dastakert	investigative	1970
15	G04-1	new	46° 12' 51.4"	39° 21' 37.6"	spring	v. Svarants	investigative	1780
16	G05-1	new	46° 03' 22.1"	39° 15' 25.7"	spring	v. Ajabaj	surveillance	2140
17	G06-1	new	46° 09' 38.3"	39° 13' 27.4"	spring	v. Geghi	surveillance	1550
18	G07-1	new	46° 06' 20.6"	39° 12' 57.0"	spring	v. Gyard	investigative	1845
19	G09-1	new	46° 19' 44.1"	39° 17' 31.8"	spring	v. Chanakhchi water intake	investigative	1190
20	G10-1	new	46° 24' 23.4"	39° 12' 31.2"	spring	t. Kapan	surveillance	780
21	G10-2	new	46° 24' 47.3"	39° 10' 03.9"	spring	v. Geghanush	surveillance	1055
22	G10-3	new	46° 23' 09.9"	39° 16' 03.5"	spring	v. Norashenik	surveillance	990
23	G10-4	new	46° 27' 07.4"	39° 16' 19.4"	spring	v. Artsvanik	surveillance	965
24	G12-1	new	46° 09' 54.0"	39° 03' 23.3"	spring	v. Lichk	surveillance	1815
25	G13-1	new	46° 09' 52.4"	39° 03' 59.2"	spring	v. Tashtun	surveillance	1935
26	G 14-1	new	46° 15' 11.7"	38° 53' 52.3"	spring	t. Meghri	investigative	640
27	G 15-1	new	46° 12' 30.4"	38° 51' 37.7"	borehole	t. Agarak	surveillance	570
28	G17-1	new	46° 22' 21.5"	38° 56' 34.2"	kyahriz	v. Shvanidzor	investigative	690
29	G19-1	new	46° 12' 43.8"	38° 58' 14.7"	spring	v. Vardanidzor	surveillance	1050

It is required to install data loggers in the new 4 boreholes for registering quantitative data which will provide for continuous and frequent data recording and better understanding of the aquifer behavior in terms of groundwater extraction and alterations of groundwater levels restoration. Prior to installation of electronic data loggers in the boreholes, groundwater level in observation wells should be measured by local observers on a monthly basis.

Quantitative groundwater monitoring: It is proposed to install automated measuring devices (level recorders) in the boreholes and furnish the springs with weirs or automated devices, which will allow recording fluctuations in the spring discharge and water levels in the wells of the Southern BMA.

***Qualitative groundwater monitoring*: The following parameters are proposed for qualitative monitoring of groundwater resources in the Southern BMA:**

1. General parameters that are measured at water source – temperature, pH, electric conductivity, dry residue.
2. Main ions - Ca, Mg, Na, K, HCO_3^-, Cl^-, SO_4^{2-}, NH_4^+, NO_3^-, NO_2^-;

3. Permanganate index (or total organic carbon);
4. Microelements - As, Cd, Pb, Hg;
5. Organic substances - polycyclic aromatic hydrocarbon, phenol, ethylene trichloride, perchloroethylene, etc.;
6. Pesticides – selection depends on the list of locally used materials, land use patterns and previously identified substances;

Organic compounds, pesticides and heavy metals in groundwater samples are monitored and determined once throughout 2-6 years in such locations, where their existence is possible. Pesticides monitoring is conducted in such monitoring points that are located in agricultural areas. Monitoring of polycyclic aromatic hydrocarbons, phenols, tetrachloroethylene and ethylene trichloride should be conducted in sites located closer to urban areas and industrial enterprises.

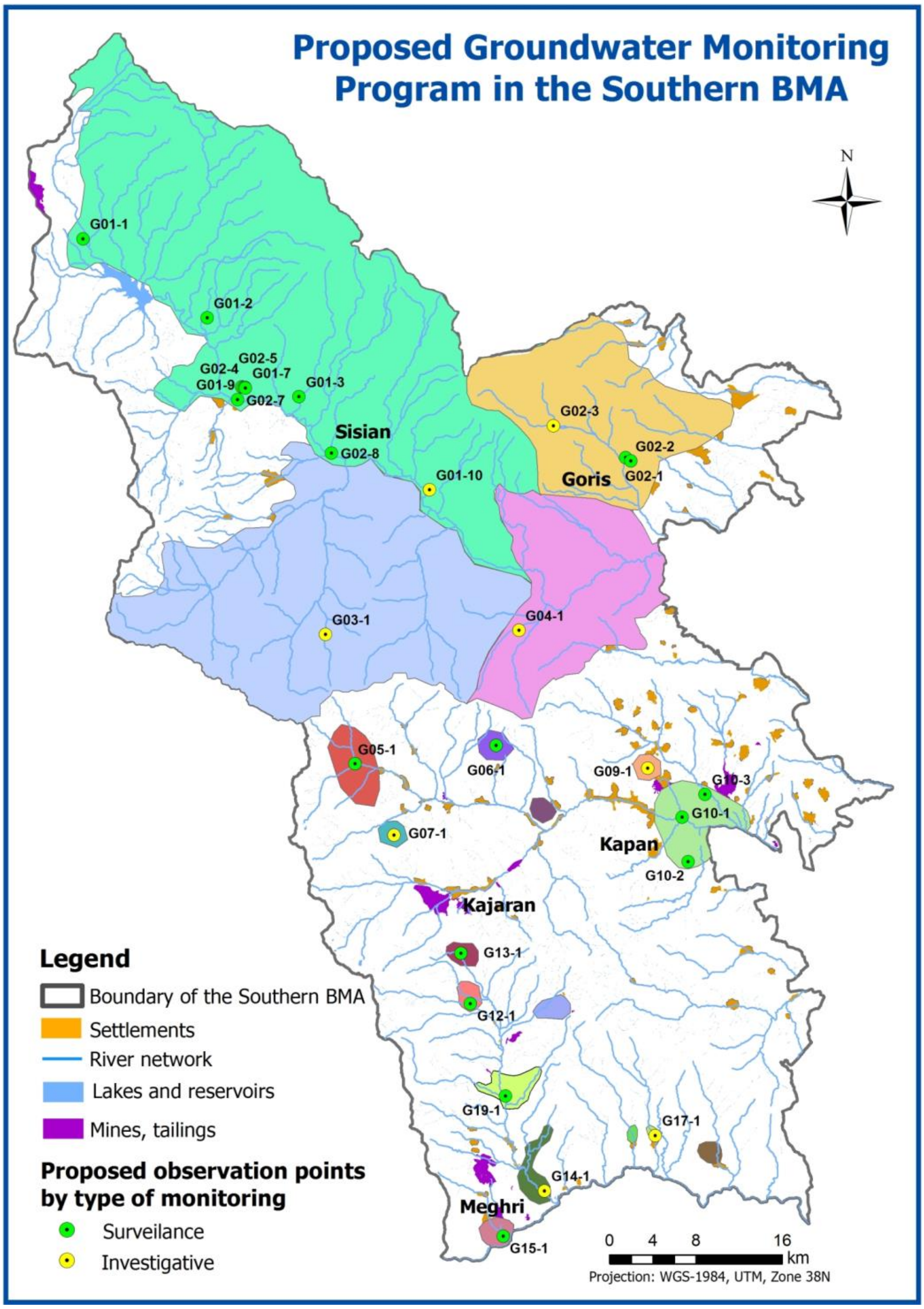


Figure 6.9: Proposed groundwater monitoring network in the Southern BMA

Source: USAID Clean Energy and Water Program, 2015

Frequency of groundwater monitoring: It is proposed to conduct surveillance monitoring of groundwater sources (natural spring or well) 4 times a year, with a purpose of determining seasonal variations of chemical composition. Frequency of sampling could be reduced to 2 times a year during the next planning cycles. Proposed frequency of groundwater resources surveillance monitoring in the Southern BMA is presented in Table 6.7.

Table 6.7: Chemical parameters and frequency of groundwater resources surveillance monitoring in the Southern BMA

Parameters and indices	***Minimum frequency***
Main anions and cations (Na, K, Ca, Mg, Fe_{gen}, NH_4, HCO_3, Cl, SO_4, NO_3, NO_2) and physical features (pH, conductivity, permanganate index or total organic carbon)	2-4 times a year
Microelements (Fe, As, Hg, Cd, Pb, Zn, Cu, Cr, etc.)	Once every 2 years
Pesticides	Once every 6 year
Polycyclic aromatic hydrocarbon, phenol, ethylene, trichlorethylene, tetrachloroethylene	Once every 2 years
Groundwater level monitoring in observation boreholes and deep wells, as well as measuring of discharge of natural springs	Once every 6-12 hours through electronic data loggers. Once per month in other monitoring observation wells

It is envisaged to conduct investigative groundwater monitoring once throughout every 2-year period, at the same time as quantitative and qualitative water monitoring is conducted. Investigative groundwater monitoring will be of an exploratory nature and will provide information on the groundwater source.

CHAPTER 7: IDENTIFICATION OF MEASURES FOR PREVENTION, MINIMIZATION AND ELIMINATION OF CONSEQUENCES OF POSSIBLE EMERGENCIES

The measures for preventing the emergencies, reducing and eliminating the consequences in the Southern BMA are also aimed at increasing the potential for climate change adaptation. The measures identified are presented below.

7.1. Furnishing of the River Banks

Natural disasters in the river basins of the Southern BMA such as flooding, mudflows, erosion cause significant damages to the houses, economic buildings etc. Such processes have been observed in the following parts of the Southern BMA:

- The Vorotan River Basin: tributaries of middle and lower reaches of the Vorotan River: left-bank Gorisget tributary, right-bank Sisian, Ashotavan, Loradzor and Tatev tributaries, as well as the Hagari River.
- The Voghji River Basin: the middle and lower reaches of the Voghji River, the left-bank Kavart, Barabatum, Norashenik and Artsvanik, as well as the right-bank Geghanush and Vachagan tributaries.
- The Meghriget River Basin: the Meghriget and Karchevan Rivers.

With the aim of strengthening the banks of the rivers that pass within the settlements in the Southern BMA, a number of measures have to be implemented, including:

- Fencing of the banks and enforcement by gabions,
- Planting trees on the river banks,
- Installation of concrete blocks,
- Provision of other temporary technical means.

The measures for stabilization and rehabilitation of the river banks in the Southern BMA are presented in Table 7.1.

7.1.1. Introduction of a Warning System

It is necessary to introduce the early warning system and monitoring services in the Southern BMA as measures to prevent floods and mudflows and mitigate impacts. These systems must be installed in the sections of rivers that are most prone to these hazards, including in the Vorotan, Voghji and Meghriget, as well as downstream the dams of the major reservoirs. Through these systems it will be possible to continuously monitor, analyze the risks and issue timely warning on the risks.

It is recommended to create a floods warning center in the river basins of the Southern BMA. The structural design of the center is given in Annex G.

It is also needed to install appropriate radio alarming/information systems that will inform about floods and mudflows that may occur. This automated system must be installed on the upper reaches of the rivers. When water levels reach a catastrophic level, radio signals/alerts will be sent to the appropriate authorities and emergency services, to undertake relevant mitigation measures in the settlements downstream.

Such systems provide the public with information on the magnitude of the destruction that may be caused by the floods or in case of failures of the reservoir dams or other hydrotechnical structures. Such systems need to be installed in the major reservoirs in the Southern BMA: upstream and downstream of the Spandaryan, Tolors, Angeghakot, Shamb, Davit-Bek and Geghi reservoirs, as well as on the flood prone sections of the Meghriget, Karchevan, Voghji, Kavart, Vachagan, Norashenik, Khoznavar and Gorisget Rivers (section 6.4).

7.1.2. Prevention and Minimization of Leaks of Dangerous Products and Lubricants

To mitigate leakage of hazardous and lubrication materials into catchments of the rivers, it is prohibited to:

1) Pollute the ice and snow cover areas and their surroundings by petroleum products, pesticides, and other hazardous substances, industrial, household and other wastes;
2) Locate waste landfills, waste dumps and other facilities in the areas where these will indirectly pose negative impact on the quality of water resources;
3) Tree logging in the water protection zones, except the sanitary cutting of the trees and with a purpose of protection of water resources.

These functions would provide for protection of water resources from potential pollution.

There were no cases recorded on major leaks of hazardous substances and lubricants into the rivers of Southern BMA. There a few car maintenance and washing stations in the towns of the Southern BMA, and according to the expert judgment, impact of lubricants, detergents and other substances on water quality is considered as not significant.

7.1.3. Control of the State of the Dams

It is necessary to implement the following measures for safety and secure maintenance of the hydrotechnical structures, including the reservoirs and dams, tunnels, as well as the tailings dams:

1) Periodic examination of the dams;
2) Maintaining operational rules for dams;
3) In case of possible accident in the dams, immediate notification of the authorities in charge of the water resources.

In case of dam's failure, the "owner/operator" of the dam shall immediately notify the RA Prime Minister. The affected population and other entities shall be also notified by means of the special information system.

The following tasks must be implemented during the examination of the dams:

- Control over the activities of the organization performing operation of the hydraulic structures: construction, reconstruction, overhaul, restoration or conservation for conformity with the safety rules and standards for protection,
- Assessment of the technical condition of the HTS.

It is necessary to create a technical committee that will review projects on the water systems safety, efficient use and maintenance of the systems with a purpose of providing professional analysis and conclusions.

Detailed assessment of the consequences of full or partial failure of the dams in the river basins of the Southern BMA is presented in the section 2.6.

7.2. Emergency Prevention Measures and Rescue Control

As a priority measure, a disaster prevention information system needs to be established to possibly minimize the damage caused by disasters. The system will make forecasts on potential water-related disasters.

The information system on floods, mudflows, landslides, erosions and droughts in the river basins of the Southern BMA shall contain current information and forecasts on:

- Occurred or potential floods, mudflows and landslides;
- Occurred or expected drought;
- Status and sustainability of natural water resources;
- Status and sustainability of important water systems (including reservoirs dams and river banks in the basin);
- Threats to public health.

Considering the low level of public awareness on disasters in the Southern BMA, public access to information on disaster risks shall be provided, particularly, for affected and vulnerable groups.

For the purpose of preventing disasters, it is prohibited to:

- Launch and use a water system, without implementing the planned preventive measures against land washing, wetland formation, salinization, and erosions;
- Fill reservoirs with water, before implementing the planned preparatory measures in reservoir basins;
- Commission and use a hydrotechnical structure in the basin, without:
  a) Completing the spillway structures for flood water;
  b) Introducing control-measuring devices and a network of observation points in dams and other important hydrotechnical structures.

There should be rescue teams in the river basins of the Southern BMA, particularly the regional center in Kapan, Goris and Meghri, with their necessary outfit and equipment. Furthermore, the area shall be furnished with construction and engineering facilities, and relevant professionals shall take a regular control of the technical state of hydrotechnical structures.

7.3. Implementation and Strengthening of Monitoring

Forecasting and prevention of emergency situations require regular monitoring and provision of data on:

- Quantitative indicators of water resources – average daily, monthly, annual water discharges and water levels, maximum and minimum water flows and periods of their occurrence;
- Qualitative indicators of water resources used for drinking and municipal/household purposes, and monthly data on levels of water pollution;
- Monthly data on qualitative indicators of water resources;
- Flood, mudflow, landslide and drought forecasts, based on annual precipitation, water resource in snow, and air temperature values from meteorological stations in the basin;
- Findings of annual studies on aquatic ecosystem protection zones;
- The degree of fullness of reservoirs in the Southern BMA, namely Spandaryan, Angeghakot, Tolors, Shamb, Davit Bek and Geghi, and values of daily water levels;
- Results of annual inspections of the technical state of the mentioned reservoir dams;
- Results of regular inspection and evaluation of the technical state of Arpa-Sevan-Vorotan tunnel;
- Prediction of rapid changes in intensity of expected atmospheric precipitation and air temperature regime.

7.4. Preventive Measures aimed at Identification and Elimination of Factors Contributing to Emergency Situations

The measures, aimed at identification and elimination of factors contributing to emergency situations in the Southern BMA, are implemented in accordance with the RA Law “On the National Water Program” and other legal acts.

The following measures are proposed to be implemented to prevent emergencies:

- Ensuring the fire control measures in hydrotechnical structures;
- Presence of structures prohibiting unauthorized access to alienation zones of hydrotechnical structures;
- Furnishing the hydrotechnical structure with measuring and control equipment, means of communication;
- Ensuring of collection, removal and washing of the sediment load generated from floods and mudflows;
- Drinking and irrigation water quality assurance, presence of a back-up pump for mechanical systems, as well as protection of the sanitary zone;
- Inclusion of the projected climate change risks and climate change adaptation measures in regional development plans;
- Dissemination of information on climate change risks and ensuring of access to climate change adaptation technologies, aimed at raising the climate change adaptation potential in the Southern BMA.

Table 7.1 provides a description of mudflow and flood control measures for potential emergencies in the Southern BMA.

Table 7.1: Preventive measures applied for potential emergencies in the Southern BMA.

#	*Location*	*Water resource*	*Description of the measure*
			Vorotan River Basin
	Sisian town	Vorotan River	Cleanup of the riverbed from silt in the town area – approximately 16000 m
	Goris town	Vararakn River	Cleanup of the riverbed in the areas called Spandaryan, Shorin Dzor, Kolatak – approximately 8800 m; renovation of the support walls – approximately 745 m; cleanup of the riverbed – 16 m in width, 1 m in depth, and 800 m in length.
	Sisian town	Haramu River	Construction of support walls in the neighborhood of Sisian and Shirak Streets – about 200 m^3.
	Uyts village	Ayriget River	Cleanup of the riverbed in the village – about 3000 m^3.
	Bnunis village	Ayriget River	Cleanup of the riverbed in the village – about 3000 m.
	Akhlatyan village	Ayriget River	Cleanup of the riverbed in the village – about 7000 m.
	Ashotavan village	Sisian River	Cleanup of the riverbed in the village – about 2000 m.
	Brnakot village	Sisian River	Cleanup of the riverbed in the village – about 12000 m.
	Brnakot village	Flood channel	Cleanup of the riverbed - 2.5 m in width, 0.6 m in depth, and 2700 m in length; construction of two bridges.
	Dastakert village	Ayriget River	Cleanup of the riverbed in the settlement area – about 500 m.
	Dastakert village	Kishtkosht River Ayriget River	Reclamation of the deteriorated part of the tailing dam and diversion of the Kishkosht River flow through a pipe.
	Nzhdeh village	Ayriget River	Cleanup of the riverbed in the village – about 500 m.
	Karahunj village	Flood channel	Cleanup of the riverbed - 4 m in width, 0.5 m in depth, and 200 m in length; reinforcement of the bank with a gabionade - 150 m in length.
			Voghji River Basin
	Geghi village	Geghi River	Cleanup of the riverbed in Geghi village area - about 600 m.
	Kavchut village in Lernadzor community	Geghi River	Construction of a bridge in Kavchut village center - 8 m in length, and 6 m in width.
	Kapan town	Kavart River	Cleanup of the Kavart riverbed - 2 m in width, 0.6 m in depth, and 3000 m in length; reinforcement of the river bank with a gabionade - 150 m in length.
	Syunik	Artsvanik River	Cleanup of the riverbed in Syunik village area – about 900 m.
			Meghriget River Basin
	Meghri town	Meghriget River	Cleanup of the riverbed in the town area – about 900 m; construction of the support walls with gabions - about 480 m.

CHAPTER 8: PRELIMINARY FINANCIAL ASSESSMENT OF IDENTIFIED MEASURES

8.1. Method of Preliminary Financial Assessment

Preliminary financial assessment of measures for strengthening the legal and institutional framework, technical measures, including those for climate change adaptability to achieving and maintaining the desirable status in the Southern BMA was conducted using data and information on costs of similar measures implemented in the RA (public governance sphere and/or within the framework of international projects), cost estimates for the best accessible technologies and good agricultural practices in Armenia and other countries, as well as localization of results of comparative analysis and assessment. When conducting cost estimates of the program of measures, the results of consultations with state authorized bodies at national and regional levels were taken into account. Exchange rate of 400 AMD per a US Dollar (USD) was applied for calculation in foreign currency and/or recalculation by foreign currency.

Sections below present preliminary financial assessment of the measures for strengthening the legal and institutional framework, technical measures in the Southern BMA, including those for prevention of emergency situations and mitigation of potential consequences, as well as the new program for surface water and groundwater resources monitoring. Sources of funding are also presented. The preliminary assessment of the costs of the measures and water resources monitoring is approximate. It provides information on implementation of the measures proposed the Southern Basin Management Plan. It also provides an opportunity for defining the priority measures on a medium-term and annual basis, with a purpose of including the priority measures on the mid-term expenditures program of the RA Government and other relevant programs and plans, as well as phased implementation of the Program of Measures.

8.2. Preliminary Financial Assessment of Measures for Strengthening Legal Framework to Achieve Desirable Status

The preliminary cost estimate for measures recommended for strengthening the legal framework targeted at achieving the desirable status and adapting to climate change in the Southern BMA, as well as sources of financing are presented below in Table 8.1.

Table 8.1: Preliminary cost estimate of the measures for strengthening the legal framework

Measure	Preliminary cost, million AMD	Source of Finance
Provision of the protection regime for Sev Lich State Sanctuary in compliance with the requirements of the RA Law On Specially Protected Natural Areas	7.5	RA State Budget, Other sources of finance not prohibited by RA legislation
Adoption of a new integrated method of calculation of ecological flow to maintain ecological status of water resources and implementation thereof	-	Within the current funding of the RA MNP, Other sources of finance not prohibited by RA legislation
	4.7	Funds allocated by international donor organizations
Development of a method of assessment of load/pressures on water resources of the Southern BMA water resources	4.5	Funds allocated by international donor organizations

Measure	Preliminary cost, million AMD	Source of Finance
Revision of the conditions defined by the water use permits of the SHPPs, including volume and regime of water abstraction, fish passes, etc., and bringing those into conformity with environmental requirements	-	Within the current funding of the RA MNP, Other sources of finance not prohibited by RA legislation
Identification of the zones that are prohibited for construction and operation of SHPPs, including special protected areas, forest areas, landslide zones, hydrological vulnerable areas	12.0	RA State Budget, Other sources of finance not prohibited by RA legislation
Development of a method for assessment of self-purification capacity of the rivers, preparation of mechanisms for its enforcement	5.7	RA State Budget, Other sources of finance not prohibited by RA legislation
Development of a concept for introduction of model farms, as well as regulations for farms management	8.2	Funds allocated by international donor organizations
Introduction of insurance systems and subsidization mechanisms aimed at protection of population of communities that are vulnerable and at risk (e.g. those with less income, settlements that are sensitive/vulnerable to natural disasters) from climate risks and to compensate for damages and losses resulting from natural disasters	6.5	Funds allocated by international donor organizations
Planning of effective land use and introduction of construction standards to protect vulnerable population from the impacts of natural disasters	-	Within the current funding of the RA MA, MTAES and other agencies, Other sources of finance not prohibited by RA legislation
Development and introduction of legal, economic and administrative incentives to reduce water losses and promote application of water saving technologies	-	Within the current funding of the RA MA, MNP, Other sources of finance not prohibited by RA legislation
Strengthening supervision mechanisms for enforcement of water use permit conditions, including determination of mechanisms for water allocation between water users during the low-flow seasons and water use optimization	-	Within the current funding of the RA MNP, Other sources of finance not prohibited by RA legislation
Adoption and enforcement of mechanisms for self-monitoring with a purpose of improving water users' accountability and reporting with a purpose of obtaining data actual on water use, wastewater removal and levels of pollution of water resources	-	Within the current funding of the RA MNP, Other sources of finance not prohibited by RA legislation
Establishment of water resources protection zones and the sanitary requirements thereof in the recreation zones	-	RA State Budget, Other sources of

Measure	Preliminary cost, million AMD	Source of Finance
		finance not prohibited by RA legislation
Inclusion of climate risks in development programs of water use sectors	5.0	RA State Budget, Other sources of finance not prohibited by RA legislation
Incorporation of climate change adaptation measures in the village and marz development programs and plans	4.0	RA State Budget, Other sources of finance not prohibited by RA legislation
Incorporation of climate change risks in key legal documents related to water resources management (the RA Water Code, RA Laws on National Water Program and Fundamental Provisions of the National Water Policy)	6.0	RA State Budget, Other sources of finance not prohibited by RA legislation
Total	**64.1**	

A major part of measures for strengthening of legal framework is function of the appropriate authorized state bodies and will be covered within the continuous annual financing of these bodies. This will not require additional financing.

Additional costs for implementation of measures aiming at strengthening the legal framework are preliminary estimated at **64.1 million AMD** or **0.16 million USD.** Allocations from the RA State budget, other sources of financing that are not prohibited by RA legislation are estimated at **40.2 million AMD** or **0.10 million USD,** while funds to be allocated by international donor organizations are estimated at **23.9 million AMD** or **0.06 million USD.**

8.3. Preliminary Financial Assessment of Measures for Strengthening Institutional Framework to Achieve Desirable Status

The preliminary cost estimate for measures recommended for strengthening the institutional framework targeted at achieving desirable status and adapting to climate change in the Southern BMA, as well as sources of financing are presented below in Table 8.2.

Table 8.2: Preliminary cost estimate of the measures for strengthening the institutional framework

Measure	Preliminary cost, million AMD	Source of Finance
Strengthening institutional capacities of the Department of Policy on Environmental Impact Assessment and Water Resources Protection, Environmental Impact Expertise Center, WRMA and its basin management organizations, State Environmental Inspectorate and its regional offices of the MNP, including equipping with state-of-the-art equipment and staff training	-	Within the current funding of the RA MNP, Syunik Marzpetaran, Other sources of finance not prohibited by RA legislation
	12.5	Funds allocated by international donor organizations

Measure	Preliminary cost, million AMD	Source of Finance
Building capacities of the EIMC of the MNP to conduct hydrobiological and hydrochemical monitoring of water resources and assess ecological status of water resources, including equipping with state-of-the-art equipment and staff training	0.0*	
Building institutional capacities of the Hydrogeological Monitoring Center of the MNP, including equipping with state-of-the-art equipment and staff training, as well as expanding the groundwater resources monitoring network	0.0*	
Building capacities of the Armenian State Hydrometeorological and Monitoring Service of the RA MTAES to conduct hydrological and hydromorphological monitoring of water resources, including equipping with state-of-the-art equipment and staff training	0.0*	
Building capacities of appropriate units of the RA MTAES for the purpose of conducting studies and projections of landslide and erosion phenomena, including furnishing with equipment	-	Within the current funding of the RA MTAES, Other sources of finance not prohibited by RA legislation
	20.0	Funds allocated by international donor organizations
Providing targeted funding (earmarking) for performing scientific-research works regarding water resources	2.0	RA State Budget, Other sources of finance not prohibited by RA legislation
Training the staff of local self-government bodies, farms and ArmForest SNCO of the RA MA to prevent diffuse/non-point pollution of water resources through correct use of fertilizers and forest restoration	4.4	Funds allocated by international donor organizations
Establishing Vorotan State Hydrological Reserve SNCO within the RA MNP and building its capacities for the purpose of protecting the flow formation area in upper reaches of the Vorotan River	15.0	RA State Budget, Other sources of finance not prohibited by RA legislation
Establishing Voghji State Hydrological Sanctuary and Lichk State Hydrological Sanctuary within the structure of the Zangezur Biosphere Complex of the RA MNP and building their capacity for the purpose of protecting the flow formation area in upper reaches of the Voghji and Meghriget Rivers	16.5	RA State Budget, Other sources of finance not prohibited by RA legislation
Establishing Shaqi Hydrological State Sanctuary within the structure of the RA MNP and building its capacities	7.5	RA State Budget, Other sources of finance not prohibited by RA legislation
Introducing/improving early warning and rapid response system for hazardous hydrometeorogical occurrences in the Southern BMA, particularly aimed at warning communities on oncoming landslide, mudflow and flood hazards	6.4	Funds allocated by international donor organizations
Strengthening data and information exchange and cooperation between key stakeholders and ensuring data accessibility/availability for analytic and research centers and projects via the State Water Cadastre Information System	-	Within the current funding of the RA MNP, MA, MTAES, Other sources of finance not prohibited by RA

Measure	Preliminary cost, million AMD	Source of Finance
		legislation
Total	**84.3**	

*the preliminary cost is included in section 8.5

A part of measures for strengthening of institutional framework is function of the appropriate authorized state bodies and will be covered within the continuous annual financing of these bodies. This will not require additional financing.

Additional costs for implementation of measures aiming at strengthening the institutional framework are preliminary estimated at **84.3 million AMD** or **0.21 million USD.** Allocations from the RA State budget, other sources of financing that are not prohibited by RA legislation are estimated at **41.0 million AMD** or **0.10 million USD,** while resources allocated by international donor organizations are estimated at **43.3 million AMD** or **0.11 million USD.**

8.4. Preliminary Financial Assessment of Technical Measures to Achieve Desirable Status

8.4.1. Preliminary cost estimate for wastewater collection and treatment in agglomerations and settlements not incorporated in agglomerations

Construction of WWTPs and sewerage collection system in agglomerations: To assess investment costs for building WWTPs and sewerage collection systems in the Goris, Sisian, Kapan, Kajaran, Meghri and Agarak agglomerations in the Southern BMA, feasibility study and design documentation for the wastewater treatment plants constructed in five urban area of the RA Gegharqunik Marz were used. Costs are estimated for construction the following units: 1 km of collector, and with 1m^3/day wastewater treatment (Table 8.3).

Table 8.3: Preliminary estimate of the investment costs for construction of the WWTPs and sewerage collector in agglomerations in the Southern BMA

Agglomera-tion	*WWTP (for construction of 1 m^3/day capacity), million AMD*	*Wastewater discharge volume per day, m^3*	*Cost of WWTP, million AMD*	*Cost for construction of 1 km collector, million AMD*	*Cost of collector, km/ million AMD*	*Total Cost, million AM)**
Sisian	1.314	10000	13140.0	32	12/384.0	13524.0
Goris	1.314	15000	19710.0	32	14/448.0	20158.0
Kapan	1.314	25000	32850.0	32.0	19.0/608.0	33458.0
Kajaran	0.657	3500	2299.5	32.0	8.3/265.6	2565.1
Meghri	0.657	2000	1314.0	32.0	7.2/230.4	1544.4
Agarak	0.657	2000	1314.0	32.0	4.7/150.4	1464.4

*Operation and maintenance costs have not been taken into account

The costs of building the Sisian, Goris and Kapan WWTPs are doubled, to provide for secondary - biological treatment phase (costs of biological treatment are 3-3.5 times higher as compared to the mechanical treatment). In case of biological treatment, the main extra cost directions relate to electricity, chemical materials used in treatment, as well as for processing of waste generated in the process and harmless removal from treatment plant. Special furnaces are used (mainly with gas consumption) for drying the biological waste.

Application of alternative methods for wastewater collection and treatment in settlements not incorporated in agglomerations: Costs for construction of biological ponds for treatment of wastewater from households and livestock production in 5 villages of the Vorotan River Basin in the Southern BMA were assessed based on data on construction of a treatment pond in the Parakar village, for 10000 inhabitants (Table 8.4).

Table 8.4 Preliminary assessment of investment costs for construction of biological treatment ponds for 5 villages in the Vorotan River Basin

#	*Settlements*	*Number of units posing pressure on water resources*	*million AMD*
1	Sarnakunq, Spandaryan	12181	99.9
2	Gorhayk	8697	71.3
3	Tsghuk	6038	49.5
4	Dastakert	1866	15.3
Total			**236.0**

Feasibility studies for implementing alternative wastewater collection and treatment methods for settlements not incorporated in agglomerations: The cost for conducting feasibility study in communities not incorporated in agglomerations in the Southern BMA is estimated based on data from the report on RA Social-Economic Conditions in January-December, 2013 prepared by the National Statistical Service of Armenia. According to the report, the monthly salary of each national expert involved in the works will comprise about 223153 AMD.

The salary fund for 6-month long study in 54 villages in the Vorotan River Basin is estimated at 5.35 million AMD (24 person/month), and costs of field works will comprise 10.0 million AMD.

The salary fund for 6-month long investigation in 26 villages in the Voghji River Basin is estimated to be 5.35 million AMD (24 person/month), and cost for performing field works - 4.8 million AMD.

The salary fund for 3-month long investigation in 9 villages in the Meghriget River basin is estimated to be 2.67 million AMD (12 person/month), and the cost for performing field works - 2.4 million AMD.

8.4.2. Preliminary Cost Estimate for Introduction of Good Agricultural Practices (GAP)

The cost for introducing GAP in the Southern basin is estimated based on the preliminary assessment of similar measures performed for the Aghstev and Debed River Basins, where the approximate cost of introducing the GAP is 130 million AMD for each village. It covers implementation of demonstration projects in pilot farms in the following directions: (a) application of effective agrotechnical measures in land use; (b) agroforestry; (c) modernization of irrigation systems with application of water saving technologies; (d) wide-scale awareness raising and educational programs addressing the behavioral change among water users. Thus, the preliminary cost for introducing the GAp in five villages in the Vorotan River Basin – Ashotavan, Darbas, Khndzoresk, Shinuhayr and Halidzor, four villages in the Voghji River Basin – Artsvanik, Norashenik, Achanan and Shikahogh, and three villages in the Meghriget River Basin – Alvanq, Vardanidzor and Lichk are estimated at 1.56 billion AMD.

The unit cost for construction of the Mukhuturyan Reservoir in the Vorotan River Basin, Norashenik Reservoir in the Norashenik River Basin and Lichk Reservoir in the Meghriget River Basin ranges between 400 and 1200 AMD per m3, based on features of terrain . The above mentioned range was provided by officials of the RA MTA State Committee of Water Committee during parliamentary hearings. The average 800 AMD was used for storing 1m^3 of water in this assessment. According to calculations, construction of Mukhuturyan Reservoir with 2,5 million m^3 designed capacity will cost 2 billion AMD. The Norashenik Reservoir with 17 million m^3 designed capacity will cost about 13.6 billion AMD, and the Lichk Reservoir with 3.8 million m^3 designed capacity will cost about 3.04 billion AMD.

Feasibility studies for installation of a small-scale localized wastewater treatment plants with a collector network to mitigate impact of return flows from the livestock farm slaughter houses on water resources are included in the works described in section 8.4.1 and do not require additional financing.

8.4.3. Preliminary Cost Estimate of Measures Recommended in the Mining Sector

Industrial wastewater discharge from mining enterprises: Both information of organizations that produce relevant technologies that are registered in internet, as well as estimates of local companies was used for preliminary estimate of costs for introducing the industrial wastewater treatment technologies. Calculations are made in accordance with the price-list recommended by producers of wastewater treatment technologies that are posted on *www.alibaba.com* website. Calculations are based on two types of wastewater treatment devices, based on the volume of wastewater that needs to the treated. The cost covers also transportation of equipment and local taxes.

It is recommended to use complex treatment plants for treatment of industrial wastewaters discharged by the Zangezur Copper-Molybdenum Combine CJSC into the Norashenik River (473000 million m^3 annually) and Agarak Copper-Molybdenum Combine CJSC (473000 million m^3 annually) discharged into the Karchevan River (473000 million m^3 annually) in the Voghji River basin. The preliminary cost for installation of such plants will make up 80 million AMD for each.

Preliminary cost for introduction of technology envisaged for treatment of wastewaters discharged by the Dundee Precious Metals Company CJSC into the Norashenik River in the Voghji River Basin is estimated to be 40 million AMD.

The cost for introducing technology for treatment of industrial wastewaters discharged directly into the Meghriger River by the Sipan-1 LLC (107 thousand m^3 annually) in the result of operation of the Lichkvaz-Tey and Terterasar small underground gold mines is also estimated at 40 million AMD.

Reclamation of waste dumps: The preliminary cost for reclamation of slopes of the waste dumps is estimated based on the closure plan of the Teghut Copper-Molybdenum Mine. Based on the total area of the dumpsites subject to reclamation and the required financing, cost for reclaiming 1 ha of the waste dump is estimated at 1.87 million AMD.

The preliminary cost estimate for reclamation of the slopes of the waste dumps operated in the Southern BMA is presented in Table 8.5.

Table 8.5: Preliminary cost estimate for reclamation of slopes of the mining waste dumpsite in the Southern BMA

Mining company	*Surface of area to be reclaimed, ha*	*Total cost, million AMD*
Zangezur Copper- Molybdenum Combine CJSC	23	43.01
Dundee Precious Metals Company CJSC	14	26.18
Agarak Copper-Molybdenum Combine CJSC	22	41.14
Sipan-1 LLC	1.2	2.24

Reclamation of eroded sections of the tailing dams: Estimates provided in the closure plan of the Teghut Copper-Molybdenum Mine were also used for preliminary cost estimate of reclamation of the tailing dams in the Voghji River Basin. According to the plan, about 2.8 million AMD is required for reclamation of 1 ha area. It is estimated, that 8.4 million AMD and 50.4 million AMD will be required for secondary reclamation of eroded sections of the Voghji (3 ha) and Pkhrut (18 ha) tailing dams, respectively.

The cost estimate for reclamation of 1 ha of the new tailing dam presented in the EIA report for the Dastakert Combine (2012) was used for estimating the costs for secondary reclamation of the eroded section of the Dastakert tailing dam. According to the EIA report, it is 4.7 million AMD per ha. About 11.75 million AMD is required for secondary reclamation of the 2.5 ha eroded area in the Dastakert tailing dam.

Rehabilitation of damaged pipelines of the tailings: The cost for rehabilitation of damaged pipelines of the Artsvanik and Geghanush tailing dams, which are polluting water in the Geghanush, Achanan and Geghi Rivers within the Voghji River Basin with new Ultra-high molecular weight polyethylene (UHMWPE) pipes, 150 linear meter in length, is estimated at 39.0 million AMD, including installation works. About 23.4 million AMD is required for rehabilitation of pipes in the Artsvanik tailing dam (90 linear m.), and 15.6 million AMD - for the Geghanush tailings pipeline (60 linear m.).

The preliminary cost for rehabilitation of a 70 m pipeline from the Agarak Copper-Molybdenum Combine to the Darazami tailing dam with Ultra-high molecular weight polyethylene (UHMWPE) pipes is estimated at 18.2 million AMD, including 14 million AMD for pipes and 4.2 million AMD for installation works.

The preliminary cost for rehabilitation of 70 m long damaged sections of the pipeline in the Karchevan River Basin that transport the tailings Hovit 1 and Hovit 2 tailing dams is estimated to be 18.2 million AMD.

Diversion of the Kishkosht River flow in the Vorotan River Basin through a pipe: The cost for diverting the flow on about 250 m long section of the Kishkosht River, which passes through the eroded part of the non-operational Dastakert tailing dam is estimated based on the RA Government Decree No. 796, as of 1999. The Decree defines the priority measures to be implemented by the RA Ministry of Industry and Trade for ensuring safety in the tailing dams of the ore concentrating plants, including construction of a new water conveyance system for the non-operational tailing dam of the Dastakert Copper-Molybdenum Combine. It was envisaged to conduct this work in 2000-2004, with 100 million AMD total funding (including 1.5 million AMD for design and 98.5 million AMD for implementation). Taking into the account the 64.9% inflation in Armenia during 2004-2013, the preliminary cost for implementing the above described works is currently 164.9 million AMD.

The preliminary cost for conducting the feasibility study for bringing the mining settling/sedimentation tanks of the Ler-Ex company with 50000 m^3 and 35000 m^3 volume into conformity with the requirements for the tailing dam is estimated at 5.0 million AMD.

The preliminary cost for installation of a small industrial water treatment plant on the tunnel reaching from the Artsvanik tailing dam to the Achanan River Basin is estimated at 40 million AMD. This is based on the cost for introducing technologies envisaged for treatment of industrial wastewater from the mining industry.

8.4.4. Preliminary Cost Estimate of Measures Proposed in Hydroenergy Sector

According to analysis conducted by the Sorgente Group, which invest s in the RA HPP sector, the preliminary cost for installation of water meters at the water abstraction points of 25 operational SHPPs in the Vorotan River Basin, 7 SHPPs in the Voghji River Basin and 4 SHPPs in the Meghriget River Basin within the Southern BMA will make up 0.4 million AMD for each SHPP. Hence, the total amount for 36 SHPPs will be 14.4 million AMD.

According to the same source, building of fish passes and bringing those in line with standards and environmental requirements currently applicable in the RA will cost 10.75 million AMD for each SHPP. Hence, the total amount for 36 SHPPs operational in the Southern BMA will be 387.0 million AMD.

8.4.5. Preliminary Cost Estimate for Measures Proposed for Solid Waste Disposal

Documents of the Program on Waste management in countries of Eastern and Central Europe and Middle Asia were used for conducing preliminary estimate of the costs for building the solid waste sanitary landfills in the Southern BMA. International standards and suitability of the site for arranging the sanitary landfills were taken into account. According to expert assessment, preliminary cost for conservation of 1 ha of the existing waste landfill is 2.8 million AMD, while for construction of 1 ha of the landfill in line with the requirements for the sanitary landfill is 243 million AMD. The annual operation and maintenance cost of the landfill is 1450 AMD per capita.

The preliminary cost for conservation of the existing 5 ha landfill in the town of Goris and 2 ha landfill in the town of Sisian in the Vorotan River Basin is estimated at 14.0 million and 5.60 million AMD, respectively. The cost for construction of the sanitary landfills in the Goris town with area of 5 ha and Sisian town with area of 2 ha is estimated at about 1.215 billion and 0.486 billion AMD respectively. The annual cost of operation and maintenance of the landfill in the Goris town with 23261 people and Sisian with 16843 people is estimated at 33.73 million and 24.42 million AMD respectively.

The preliminary cost for conservation of the existing 4 ha landfill in the Kapan town is estimated at 11.2 million. The cost for construction of the sanitary landfill with area of 9 ha is estimated at about 2106 million AMD. The annual cost of operation and maintenance of the landfill serving the Kapan town and adjacent Syunik village with 44627 people is estimated at 64.71 million AMD.

The preliminary cost for conservation of the existing 2 ha landfill in the Meghri town is estimated at 5.60 million. The cost for construction of the sanitary landfill with area of 2 ha is estimated at about 486 million AMD. The annual cost of operation and maintenance of the landfill serving the Meghri town and adjacent Lehvaz village with 5223 people is estimated at 7.57 million AMD. The preliminary cost for conservation of the existing 3 ha landfill in the Agarak town is estimated at 8.40 million. The cost for construction of the sanitary landfill with area of 3 ha is estimated at about 729 million AMD. The annual cost of operation and maintenance of the landfill serving the Agarak town and adjacent Karchevan village with 5000 people is estimated at 7.25 million AMD.

8.4.6. Preliminary Cost Estimate of Measures to Prevent Potential Emergency Situations

The preliminary costs for implementing measures aiming at prevention of potential emergency situations and reduction of their possible consequences in the river basins of the Southern BMA is assessed based on the costs of similar works implemented by public expenditures, as well as comparative analysis of costs for works implemented in other countries and by localization of the cost estimates.

The preliminary cost estimate for prevention of mud-flows and floods during potential emergency situations in the Southern BMA is presented in Table 8.6.

Table 8.6: Preliminary assessment of costs for prevention of mud-flows and floods during potential emergency situations in the Southern BMA

Name of Measure	Quantity	Unit cost, AMD	Preliminary cost, million AMD
Vorotan River Basin			
Cleaning the Vorotan riverbed from silt in the territory of the Sisian town	16000 m	1200	19.20
Cleaning the Vararakn River bed within the town of Goris in the following stretches: Spandaryan, Shorin Dzor, Sandi Dzor, Kolatak	8800 m	1200	10.56
Rehabilitation of support walls of the Vararakn River in the town of Goris, in the following stretches: Shorin Dzor, Sandi Dzor and Kolatak	745 m	225000	167.63

Name of Measure	Quantity	Unit cost, AMD	Preliminary cost, million AMD
Cleaning the Vararakn riverbed in the territory of the Goris town – 16m long and 1m deep	800 m	1200	0.96
Constructing a support wall for the Haramu River in the vicinity of Sisian and Shirak streets in the territory of the Sisian town	200 m	225000	45.00
Cleaning the Ayriget riverbed in the territory of the Uyts village	3000 m	1200	3.60
Cleaning the Ayriget riverbed in the territory of the Bnunis village	3000 m	1200	3.60
Cleaning the Ayriget riverbed in the territory of the Dastakert village	500 m	1200	0.60
Cleaning the Ayriget riverbed in the territory of the Nzhdeh village	500 m	1200	0.60
Cleaning the Ayriget riverbed in the territory of the Akhlatyan village	7000 m	1200	8.40
Cleaning the Sisian riverbed in the territory of the Ashotavan village	2000 m	1200	2.40
Cleaning the Sisian riverbed in the territory of the Brnakot village	12000 m	1200	14.40
Cleaning the flood channel bed in the territory of Brnakot village – 2.5 m long and 0.6 m deep	2700 m	1200	3.24
Construction of bridges in the territory of Brnakot village	2 units	25000000	50.00
Cleaning the flood channel bed in the territory of the Karahunj village –4 m long and 0.5 m deep	200 m	1200	0.24
Reinforcement of the flood channel bank by gabions in the territory of Karahunj village	150 m	225000	33.75
Voghji River Basin			
Cleaning the Geghi riverbed in the territory of the Geghi village	600 m	1200	0.72
Construction of a bridge for Kavchut village in the Lernadzor village – 8 m long and 6 m wide	1 unit	25000000	25.00
Cleaning the Kavart riverbed in the territory of the Kapan town – 2 m long and 0.6 m deep	3000 m	120000	3.60
Reinforcement of the Kavart river bank by gabions in the territory of the Kapan town	150 m	225000	33.75
Cleaning the Norashenik riverbed in the territory of Syunik village	900 m	1200	1.08
Meghriget River Basin			
Cleaning the Meghriget riverbed in the territory of the Meghri town	900 m	1200	1.08
Reinforcement of the Meghriget River bank by gabions in the territory of the Meghri town	480 m	225000	108.000
Total			***537.41***

Preliminary cost for implementation of measures aiming at prevention of mud-flows and floods in potential emergency situations within the Southern BMA is estimated at **537.41 million AMD or 1.34 million USD,** including for the Vorotan River Basin - 368.14 million AMD or 0.91 million USD, the Voghji River Basin - 64.15 million AMD or 0.16 million USD, and the Meghriget River Basin - 109.08 million AMD or 0.27 million USD.

The preliminary cost estimate for technical measures, including those for prevention of mud-flows and floods in emergency situations proposed for achieving desirable status in the Southern BMA, as well as the financing sources are presented below in Table 8.7.

Table 8.7: Preliminary cost estimate for technical measures proposed for achieving desirable status in the Southern BMA and sources of financing

	Name of measure	Unit	Quantity	Unit cost, million AMD	Total cost, million AMD	Source of Finance
1.	Construction of WWTP in the Sisian Agglomeration	m^3/day	10000	1.314	13140.0	Water supply organization – 10%, International donor organizations or local, foreign foundations– 90%
2.	Construction of sewerage collector in the Sisian Agglomeration	km	12	32.0	384.0	Water supply organization – 10%, International donor organizations or local, foreign foundations– 90%
3.	Construction of WWTP in the Goris Agglomeration	m^3/day	15000	1.314	19710.0	Water supply organization – 10%, International donor organizations or local, foreign foundations– 90%
4.	Construction of sewerage collector in the Goris Agglomeration	km	14	32.0	448.0	Water supply organization – 10%, International donor organizations or local, foreign foundations– 90%
5.	Construction of WWTP in the Kapan Agglomeration	m^3/day	25000	1.314	32850.0	Water supply organization – 10%, International donor organizations or local, foreign foundations– 90%
6.	Construction of sewerage collector in the Kapan Agglomeration	km	19	32.0	608.0	Water supply organization – 10%, International donor organizations or local, foreign foundations– 90%
7.	Construction of WWTP in the Kajaran Agglomeration	m^3/day	3500	0.657	2299.5	Water supply organization – 10%, International donor organizations or local, foreign foundations– 90%
8.	Construction of sewerage collector in the Kajaran Agglomeration	km	8.3	32.0	265.6	Water supply organization – 10%, International donor organizations or local, foreign foundations– 90%
9.	Construction of WWTP in the Meghri Agglomeration	m^3/day	2000	0.657	1314.0	Water supply organization – 10%, International donor organizations or local, foreign foundations– 90%
10.	Construction of sewerage collector in the Meghri Agglomeration	km	7.2	32.0	230.4	Water supply organization – 10%, International donor organizations or local, foreign foundations– 90%
11.	Construction of WWTP in the Agarak Agglomeration	m^3/day	2000	0.657	1314.0	Water supply organization – 10%, International donor organizations or local, foreign foundations– 90%
12.	Construction of sewerage collector in the Agarak Agglomeration	km	4.7	32.0	150.4	Water supply organization – 10%, International donor organizations

	Name of measure	Unit	Quantity	Unit cost, million AMD	Total cost, million AMD	Source of Finance
						or local, foreign foundations– 90%
13.	Construction of biological treatment ponds for 5 villages in the Vorotan River basin	pond	5	See table 8.4	236.0	Community budget - 10% International donor organizations or local or foreign foundations - 90%
14.	Feasibility study for wastewater treatment methods for 54 villages not incorporated in agglomerations in the Vorotan River Basin	man/ month	24	0.223	5.35	RA State budget - 50% International donor organizations or local or foreign foundations - 50%
		month	6	1.67	10.02	
15.	Feasibility study for wastewater treatment methods for 26 villages not incorporated in agglomerations in the Voghji River Basin	man/ month	24	0.223	5.35	RA State Budget - 50% International donor organizations or local or foreign foundations - 50%
		month	6	0.8	4.8	
16.	Feasibility study for wastewater treatment methods for 9 villages not incorporated in agglomerations in the Meghriget River Basin	person/ month	12	0.223	2.67	RA State budget - 50% international donor organizations or local or foreign foundations - 50%
		month	3	0.8	2.4	
17.	GAP introduction program	village	12	130.0	1560.0	International donor organizations or local or foreign foundations
18.	Construction of the Mukhuturyan Reservoir	m^3	2500000	0.0008	2000.0	RA State budget - 30% International donor organizations or local or foreign foundations - 70%
19.	Construction of the Norashenik Reservoir	m^3	17000000	0.0008	13600.0	
20.	Construction of the Lichk Reservoir	m^3	3800000	0.0008	3040.0	
21.	Introducing wastewater treatment technologies for the Zangezur Copper-Molybdenum Combine	unit	1	80.0	80.0	Private investor
22.	Introducing wastewater treatment technologies for the Dundee Precious Metals Company	unit	1	40.0	40.0	Private investor
23.	Introducing wastewater treatment technologies for the Agarak Copper-Molybdenum Combine	unit	1	80.0	80.0	Private investor
24.	Introducing wastewater treatment technologies for the Sipan-1 LLC	unit	1	40.0	40.0	Private investor
25.	Reclamation of the waste dump slopes of the Zangezur Copper-Molybdenum Combine	ha	23	1.87	43.01	Private investor
26.	Reclamation of the waste dump slopes of the Dundee Precious Metals Company	ha	14	1.87	26.18	Private investor

	Name of measure	Unit	Quantity	Unit cost, million AMD	Total cost, million AMD	Source of Finance
27.	Reclamation of the waste dump slopes of the Agarak Copper-Molybdenum Combine	ha	22	1.87	41.14	Private investor
28.	Reclamation of the waste dump slopes of the Lichvaz-Tey mine of the Sipan-1 LLC	ha	1.2	1.87	2.24	Private investor
29.	Reclamation of the eroded sections of the reclaimed Dastakert tailing dam	ha	2.5	4.7	11.75	Private investor
30.	Reclamation of the eroded sections of the reclaimed Voghji tailing dam	ha	3	2.8	8.4	Private investor
31.	Reclamation of the eroded sections of the reclaimed Pkhrut tailing dam	ha	18	2.8	50.4	Private investor
32.	Rehabilitation of damaged sections of the Artsvanik tailing dam pipeline	lm	90	0.26	23.4	Private investor
33.	Rehabilitation of damaged sections of the Geghanush tailing dam pipeline	lm	60	0.26	15.6	Private investor
34.	Rehabilitation of damaged sections of the Darazami tailing dam pipeline	lm	70	0.26	18.2	Private investor
35.	Rehabilitation of damaged sections of the damaged pipeline delivering tailings to the Hovit 1 and Hovit 2 tailing dams	lm	70	0.26	18.2	Private investor
36.	Diversion of the Kishkosht River flow via pipe	unit	1	164.9	164.9	RA State budget
37.	Feasibility study for bringing the settling/sedimentation tanks of the Ler-Ex company into conformity with the requirements for the tailing dams (50000 m^3 and 35000 m^3)				5.0	Private investor
38.	Installation of a small industrial water treatment plant on the tunnel reaching the Achanan River basin from the Artsvanik tailing dam	unit	1	40.0	40.0	Private investor
39.	Installation of water meters at water abstraction points of the SHPPs	unit	36	0.4	14.4	Private investor
40.	Building fish passes for the SHPPs	unit	36	10.75	387.0	Private investor
41.	Conservation the existing Goris landfill	ha	5	2.8	14.00	Community Budget - 10% International donor organizations or local or foreign foundations – 90%
42.	Construction of the Goris sanitary landfill	ha	5	243	1215.0	Community budget – 10% International donor organizations or local or foreign foundations – 90%

	Name of measure	Unit	Quantity	Unit cost, million AMD	Total cost, million AMD	Source of Finance
43.	Operation of the Goris sanitary landfill (for six years)	person	23261	0.00145	202.37	Community budget
44.	Conservation the existing Sisian landfill	ha	2	2.8	5.60	Community budget - 10% International donor organizations or local or foreign foundations – 90%
45.	Construction of the Sisian sanitary landfill	ha	2	243	486.0	
46.	Operation of the Sisian sanitary landfill (for six years)	person	16843	0.00145	146.53	Community budget
47.	Conservation the existing Kapan landfill	ha	4	2.8	11.20	Community budget - 10% International donor organizations or local or foreign foundations – 90%
48.	Construction of the Kapan sanitary landfill	ha	9	234	2106.0	
49.	Operation of the Kapan sanitary landfill (for six years)	person	44627	0.00145	388.26	Community budget
50.	Conservation the existing Meghri landfill	ha	2	2.8	5.60	Community budget 10% International donor organizations or local or foreign foundations – 90%
51.	Construction of the Meghri sanitary landfill	ha	2	243	486.0	
52.	Operation of the Meghri sanitary landfill (for six years)	person	5223	0.00145	45.42	Community budget
53.	Conservation the existing Agarak landfill	ha	3	2.8	8.40	Community budget - 10% International donor organizations or local or foreign foundations – 90%
54.	Construction of Agarak sanitary landfill	ha	3	243	729.0	
55.	Operation of the Agarak sanitary landfill (for six years)	person	5000	0.00145	43.5	Community budget
56.	Cleaning the Vorotan riverbed from silt in the territory of the Sisian town	m	16000	1200	19.20	RA State budget
57.	Constructing a support wall for the Haramu River in the vicinity of Sisian and Shirak streets in the territory of the Sisian town	m	200	225000	45.00	RA State budget
58.	Cleaning the Vararakn River bed within the town of Goris in the following stretches: Spandaryan, Shorin Dzor, Sandi Dzor, Kolatak	m	8800	1200	10.56	RA State budget
59.	Rehabilitation of support walls of the Vararakn River in the town of Goris, in the following stretches: Shorin Dzor, Sandi Dzor and Kolatak	m	745	225000	167.63	RA State budget
60.	Cleaning the Vararakn riverbed in the territory of the Goris town – 16 m long and 1m deep	m	800	1200	0.96	RA State budget
61.	Cleaning the Ayriget riverbed in the territory of the Uyts village	m	3000	1200	3.60	RA State budget
62.	Cleaning the Ayriget riverbed in the territory of the Bnunis village	m	3000	1200	3.60	RA State budget
63.	Cleaning the Ayriget riverbed in the territory of the Dastakert village	m	500	1200	0.60	RA State budget

	Name of measure	Unit	Quantity	Unit cost, million AMD	Total cost, million AMD	Source of Finance
64.	Cleaning the Ayriget riverbed in the territory of the Nzhdeh village	m	500	1200	0.60	RA State budget
65.	Cleaning the Ayriget riverbed in the territory of the Akhlatyan village	m	7000	1200	8.40	RA State budget
66.	Cleaning the Sisian riverbed in the territory of the Ashotavan village	m	2000	1200	2.40	RA State budget
67.	Cleaning the Sisian riverbed in the territory of the Brnakot village	m	12000	1200	14.40	RA State budget
68.	Cleaning the flood channel bed in the territory of Brnakot village – 2.5 m long and 0.6 m deep	m	2700	1200	3.24	RA State budget
69.	Construction of bridges in the territory of Brnakot village	unit	2	25000000	50.00	RA State budget
70.	Cleaning the flood channel bed in the territory of the Karahunj village –4 m long and 0.5 m deep	m	200	1200	0.24	RA State budget
71.	Reinforcement of the flood channel bank by gabions in the territory of Karahunj village	m	150	225000	33.75	RA State budget
72.	Cleaning the Geghi riverbed in the territory of the Geghi village	m	600	1200	0.72	RA State budget
73.	Construction of a bridge for Kavchut village in the Lernadzor village – 8 m long and 6 m wide	unit	1	25000000	25.00	RA State budget
74.	Cleaning the Kavart riverbed in the territory of the Kapan town – 2 m long and 0.6 m deep	m	3000	120000	3.60	RA State budget
75.	Reinforcement of the Kavart river bank by gabions in the territory of the Kapan town	m	150	225000	33.75	RA State budget
76.	Cleaning the Norashenik riverbed in the territory of Syunik village	m	900	1200	1.08	RA State budget
77.	Cleaning the Meghriget riverbed in the territory of the Meghri town	m	900	1200	1.08	RA State budget
78.	Reinforcement of the Meghriget River bank by gabions in the territory of the Meghri town	m	480	225000	108.000	RA State budget
	Total				**100654.99**	

* Funds allocated by international donor organizations or local or foreign funds: grants, loans or other type of allocations

The preliminary cost for proposed technical measures, including those aiming at prevention of mud-flows and floods in emergency situations is estimated at **100654.9 million AMD** or **251.6 million USD.** Allocations from the RA State budget are estimated at about **6309.6 million AMD** or **15.77 million USD;** allocations from community budgets are estimated at **1291 million AMD** or **3.23 million USD;** funds to be allocated by international donor organizations and/or local or foreign funds – **84838 million AMD** or **121.1 million USD.** Investment costs to be made by the private companies and water supply organizations are preliminary estimated respectively at **944.92 million AMD** or **2.36 USD** and **7271.39 million AMD** or **18.178 million USD**.

8.5. Preliminary Financial Assessment of Proposed New Program for Water Resources Monitoring to Achieve Desirable Status

The preliminary estimate of costs for proposed new program of surface water and groundwater resources monitoring to achieve the defined environmental objectives in the Southern BMA is based on the current budgets and mid-term expenditures program of the EIMS and HMC of the RA MNP, Armstatehydromet Service of the RA MTAES. Preliminary costs of monitoring some chemical parameters in water resources, as well as surface water biological and hydromorphological monitoring proposed within the new program is estimated based on all types of costs, including those for sampling, field work, materials, utility costs necessary to conduct monitoring, as well as current average salary rates in Armenia. The data on cost of field investigations conducted within the frames EU-funded Program on Environmental Protection of International River Basins (EPIRB) is used for estimating the costs for those monitoring types that are not implemented in Armenia.

New surface water monitoring program: the preliminary cost estimate for new surface water resources monitoring program in the Southern BMA is presented in Table 8.8.

Table 8.8: Preliminary estimate of costs for new surface water monitoring program in the Southern BMA

Surface water monitoring	*Parameter*	*Monitoring type in the observation point*	*Frequency*	*Unit cost, million AMD*	*Number of observation points*	*Total cost for the first-6 year planning cycle, million AMD*
Physical - chemical	Main physical and chemical parameters. heavy metals	operational and pollutants transfer	12 times a year	0.089	28	179.424
		surveillance	6-7 times a year	0.089	4	13.884
		reference	4 times a year	0.089	10	21.360
		investigative	1 time in 2 years	0.089	2	0.534
	WFD primary and specific pollutants	operational and pollutants transfer	4 times a year	0.046	28	30.912
		surveillance	4 times a year	0.046	4	4.416
		reference	4 times a year	0.046	10	11.040
Biological	Macroinvertebrates	all types, except the investigative	1 time a year	0.0216	42	5.443
		investigative	1 time in 2 years	0.0216	2	0.130
Silt	Heavy metals	only operational and pollutants transfer	1 time in 2 years	0.0675	28	5.670
Hydrological	Hydrological parameters	operational and pollutants transfer	12 times a year	0.0405	28	81.648
		surveillance	6-7 times a year	0.0405	4	6.318
		reference	4 times a year	0.0405	10	1.620

Surface water monitoring	Parameter	Monitoring type in the observation point	Frequency	Unit cost, million AMD	Number of observation points	Total cost for the first-6 year planning cycle, million AMD
		investigative	1 time in 2 years	0.0405	2	0.243
Hydromorphological	Morphological parameters	operational and pollutants transfer	2 times a year	0.027	28	9.072
		surveillance and reference	1 time a year	0.027	14	2.268
		investigative	1 time in 2 years	0.027	2	0.162
Total						**374.420**

The preliminary cost for conducting surface water monitoring in the Southern BA during the first 6-year planning cycle is estimated at 374.42 million AMD, including 261.8 million AMD for physico-chemical, 5.6 million AMD – for biological, 5.7 million AMD - for silt, 89.8 million AMD - for hydrological and 11.5 million AMD - hydromorphological monitoring. About 2.4 million AMD is needed for furnishing each observation point. Thus, the preliminary cost for establishing the proposed 34 new observations points is estimated at 81.6 million AMD. In overall, the proposed news surface water monitoring program will cost **456.02 million AMD** or **1.14 million USD.**

New groundwater monitoring program: the preliminary cost estimates for drilling new observation wells and furnishing those with electric water-level and temperature recorders, as well as conducting quantitative and qualitative groundwater monitoring in the Southern BMA are presented below in Tables 8.9 and 8.10.

Table 8.9: Preliminary cost estimate for drilling new hydrogeological observation wells in the Southern BMA and furnishing those with equipment

Measure	*Unit cost, million AMD*	*Number of observation wells*	*Total cost for the first-6 year planning cycle, million AMD*
Developing design and tender documentation package	2.3	4	9.1
Drilling hydrogeological observation wells	15.1	4	60.5
Furnishing observation wells with equipment, including remote control device for data transfer	3.8	4	15.1
Total			**85.6**

Table 8.10: Preliminary cost estimate of new groundwater monitoring program in the Southern BMA

	Parameter	*Type of monitoring*	*Frequency*	*Unit cost, million AMD*	*Number of observation points*	*Total cost for the first-6 year planning cycle, million AMD*
Qualitative	General chemical and physical parameters	surveillance	2-4 times a year	0.041	20	14.760
		investigative	1 time in 2 years	0.041	8	0.984
	Microelements	surveillance	1 time in 2 years	0.048	20	2.880
		Investigative	1 time in 6 years	0.048	8	0.384
	Pesticides	all types	1 time in 6 years	0.024	28	0.672
	Organic pollutants	surveillance	1 time in 2 years	0.022	20	1.320
		Investigative	1 time in 6 years	0.022	8	0.176
Quantitative	Hydrological measurements	surveillance	1 time a month (or every 6-12 hours by loggers	0.0405	20	58.320
		investigative	4 times a year	0.0405	6	5.832

	Parameter	Type of monitoring	Frequency	Unit cost, million AMD	Number of observation points	Total cost for the first-6 year planning cycle, million AMD
			2 times a year for boreholes and kyahrizes	0.0405	2	0.972
Total						**86.3**

The total cost for conducting groundwater monitoring in the Southern BMA for the first 6-year planning cycle is preliminarily estimated **171.9 million AMD** or **0.43 million USD.**

The following sources are proposed for financing the establishment and implementation of the proposed new program of water resources monitoring program in the Southern BMA, which is estimated at **627.92 million AMD** or **1.57 million USD**:

- RA State budget, other sources of finance not prohibited by RA legislation - 50% of the total cost. This will not exceed allocations made currently from the RA State Budget for quantitative and qualitative monitoring of surface and groundwater resources in the southern BAM (Table 10.5);
- International donor organizations – 50% of the total cost.

8.6. Conclusions and Recommendations

The total cost of implementation of legal, institutional and technical measures, including those addressing climate change adaptability and prevention of potential emergency situations and reduction of the likely hazards thereof, as well as of the new surface and ground water monitoring program over the first 6-year management planning cycle in the Southern Basin is preliminary estimated at **101117.35 million AMD** or **252,79 million USD** (Table 8.11). This amount does not include cost for those measures, which are functions of state authorities and funded continuously from the RA State Budget, other sources of financing which are not prohibited by the RA legislation.

Table 8.11: Preliminary financial assessment of measures proposed for achieving desirable status in the Southern BMA and proposed sources of financing

Name of measure	Source of Financing	Amount	
		million AMD	*million USD*
Strengthening legal framework	RA State budget, other sources of finance not prohibited by RA legislation*	40.20	0.10
	International donor organizations	23.90	0.06
Total		***64.10***	***0.16***
Strengthening institutional framework	RA State budget, other sources of finance not prohibited by RA legislation*	41.00	0.10
	international donor organizations	43.30	0.11
Total		***84.30***	***0.21***
Technical measures, including those addressing climate change adaptability and prevention of potential emergency situations	RA State budget, other sources of finance not prohibited by RA legislation	6309.60	15.78
	Community budget, other sources of finance not prohibited by RA legislation	1290.75	3.23
	International donor organizations and/or local or foreign foundations	84838.32	212.09
	Private investors	944.92	2.36
	Water supply organizations	7271.39	18.18

Name of measure	Source of Financing	Amount	
		million AMD	*million USD*
Total		***100654.99***	***251.64***
Water resources new monitoring program	RA State budget, other sources of finance not prohibited by RA legislation	within the continuous annual financing	
	International donor organizations and/or local or foreign foundations	313.96	0.78
Total		***313.96***	***0.78***
TOTAL		**101117.35**	**252.79**

* presents resources that are needed in addition to continuous allocations from the RA State Budget, other sources of financing which are not prohibited by the RA legislation for water management and protection

Recommended sources of finance for implementation of measures for achieving the environmental objectives in the Southern BMA as set forth by the management plan are:

- RA State budget, other sources finance that are not prohibited by RA legislation – 6390.80 million AMD, 15.98 million USD or about 6.3% of the total finance;
- International donor organizations and/or local or foreign foundations – 85219.48 million AMD, 213.05 million USD or about 84.3% of the total finance;
- Community budget – 1291 million AMD, 3.22 million USD or about 1.3% of the total finance;
- Private investors – 944.2 million AMD, 2.36 million USD or 0.9% of the total finance;
- Water supply organizations – 7271.4 million AMD, 18.18 million USD or about 7.2% of the total finance.

The priority measures were defined by the key stakeholder government agencies for implementation during 2016-2021 – the first 6-year management planning cycle in terms of increasing management efficiencies and protection of water resources in the Southern BMA, as well as financial considerations. The rest of measures will be implemented in the following management planning cycles, after updating of the management plan. The priority measures are as follow:

Strengthening the institutional and legal framework: additional finance (in addition to financial resources continuously provided to the state authorities from the state budget, other sources of financing not prohibited by RA legislation) required for implementation of measures proposed in this management plan for strengthening legal and institutional framework is preliminary estimated at 148.4 million AMD or 0.37 million USD. Allocations from the RA state budget, other sources of finance that are not prohibited by RA legislation are estimated at 81.2 million AMD or 0.20 million USD, and from international donor organizations – 67.2 million AMD or 0.17 million USD.

- ***Reduction of pressures from the mining industry on quality and quantity of water resources:*** the preliminary cost for implementing technical measures for reducing pressures from the mining industry as proposed in this management plan is estimated at about **945 million AMD** or **2.4 million USD**. The finance source for the investment programs is the private sector – mining enterprises.

- ***Construction of WTTPs and sewerage collectors in agglomerations of the Southern BMA:*** construction of the WTTPs and sewerage collectors is proposed for the Sisian, Goris, Kapan, Kajaran, Meghri and Agarak agglomerations of the Southern basin, with total cost estimated at **72714 million AMD** or **181.8 million USD**.

  Taking into consideration shortage of finance as a result of financial and economic hardship, it is proposed to build the WTTPs and sewerage collection network in the Sisian, Kapan and Meghri agglomerations of the Southern BMA during the first 6-year planning cycle. The investment costs are preliminary estimated at **67140.0 million AMD** or **167.9 million USD**. Allocations from international donor organizations, local or foreign foundations are estimated at **60426.0 million AMD** or **151.10 million USD**, or 90% of total investment cost. Co-finance by the RA GOA and/water supply company is estimated at **6714.0 million AMD** or **16.8 million USD**, or 10% of the investment cost.

- ***Establishment and implementation of new program for water resources monitoring in the Southern BMA:*** the additional finance (in addition to financial resources continuously provided to the state authorities from the state budget, other sources of financing not prohibited by RA legislation) needed for establishment and implementation of the new program proposed in this management plan for monitoring quality and quantity of surface and groundwater resources in the Southern BMA is estimated at **313.96 million AMD** or **0.78 million USD**. This cost is expected to be covered by international donor organizations.

The preliminary cost for implementing priority measures identified by the key stakeholder authorities in the Southern BMA during 2016-2021 – the first six-year planning management cycle, is estimated at 68547.38 million AMD or 171.37 million USD, to be covered from the following sources: the RA State budget, other sources of finance not prohibited by RA legislation – about 6795.2 million AMD or 16.99 million USD; international donor organizations or other foundations – about 60807.16 million AMD or 152.01 million USD; private sector (mining enterprises) – 945 million AMD and 2.4 million USD.

CHAPTER 9: PUBLIC AND STAKEHOLDER PARTICIPATION IN DECISION MAKING

9.1. Identification of Issues Requiring Public Hearings

Effective management and protection of water resources of the Southern BMA is important for socioeconomic development of the region. The achievement of the environmental objectives defined under this Southern Basin Management Plan will foster public welfare and sustainable management of natural resources.

Stakeholder, including public participation in integrated water resources management has been ensured in various stages of development of this draft management plan, including the stages of natural and anthropogenic pressure-impact analyses, and development of the proposed program of measures to achieve desirable status in the Vorotan, Voghji and Meghriget River Basins of the Southern BMA. A special questionnaire was used during public hearings (Annex H).

9.2. Analyses of Findings of Field Studies and Public Hearings

Over 80 participants from the Vorotan, Voghji and Meghriget River Basins, including affected community members, major water users, representatives of local self-government authorities, decision makers, etc., completed the questionnaire during development of the draft Southern Basin Management Plan and Vorotan, Voghji and Meghriget RBMPs. Sections 9.3-9.7 provide a summary of stakeholder inputs as a result of completion of questionnaires.

9.3. Measures to Control Water-Related Disasters

About 48% of the respondents mentioned mudflows, 31% - floods, and 21% - snowmelt as the main water-related disasters in the basin (Figure 9.1). None of the respondents noted there were no water-related disasters in the river basins.

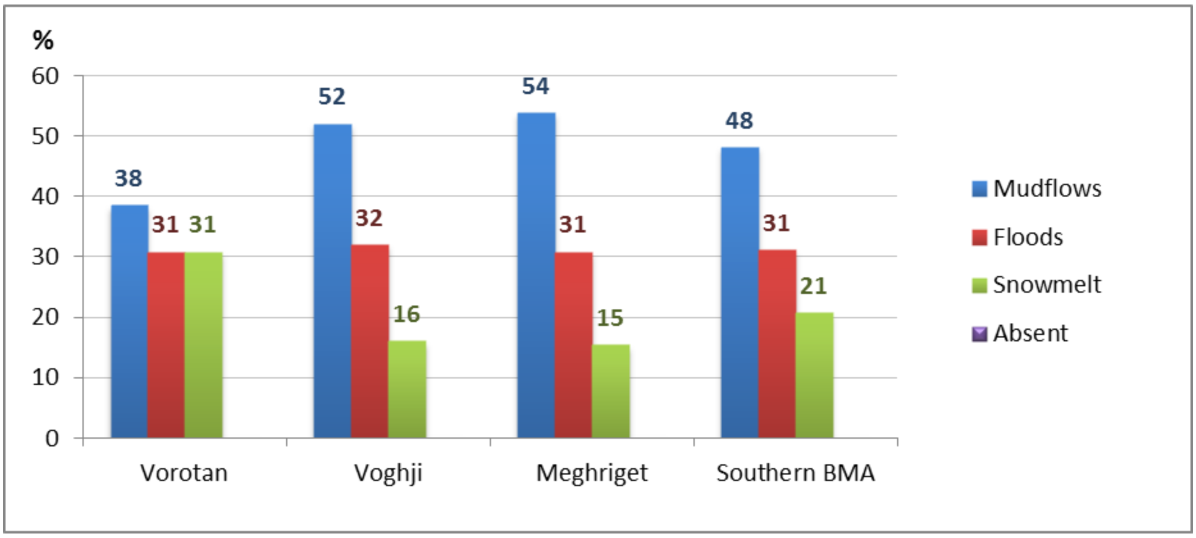


Figure 9.1: Main water-related disasters in the Southern BMA

36% of the respondents believed that water-related disasters caused damage to infrastructures – bridges, roads, and other hydrotechnical structures, 30% to arable lands, and 24% to land plots. 10% of the respondents mentioned that domestic animals suffered from water-related disasters (Figure 9.2).

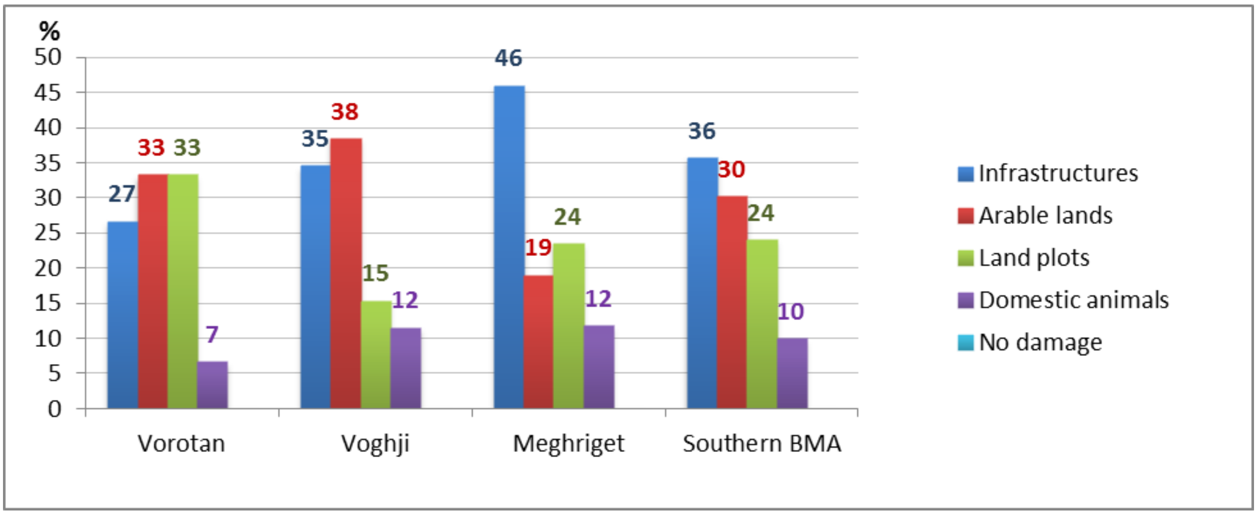


Figure 9.2: Damage caused by water-related disasters in the Southern BMA

The principal part (approximately 85%) of the respondents found it difficult to assess the amount of damage caused by water-related disasters.

48% of the respondents mentioned mudflow control structures, 33% - development of the wastewater collection system, and 19% - water flow regulation, as a measure to control water related-disasters (Figure 9.3).

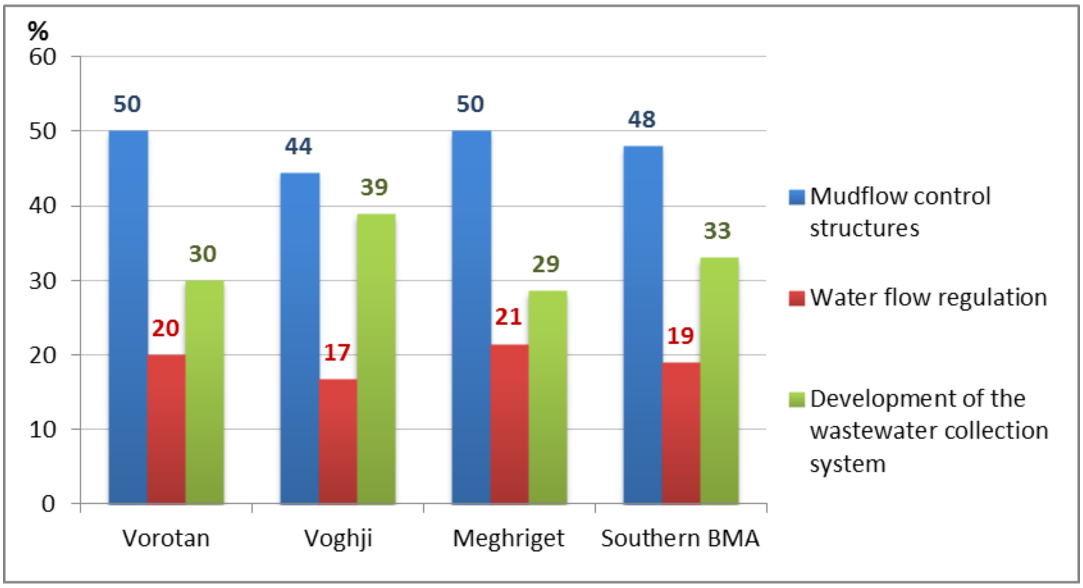


Figure 9.3: Proposed measures to control water-related disasters in the Southern BMA

9.4. Water Use

The majority (43%) of respondents mentioned that water use was mostly irrational (61% of the respondents in the Voghji River Basin), only 6 % - extremely irrational, and 32% - mostly rational (56% of the respondents in the Vorotan River Basin) in the Southern BMA. Very few respondents (6%) believed the water use to be rational, and 13% found it difficult to answer (Figure 9.4).

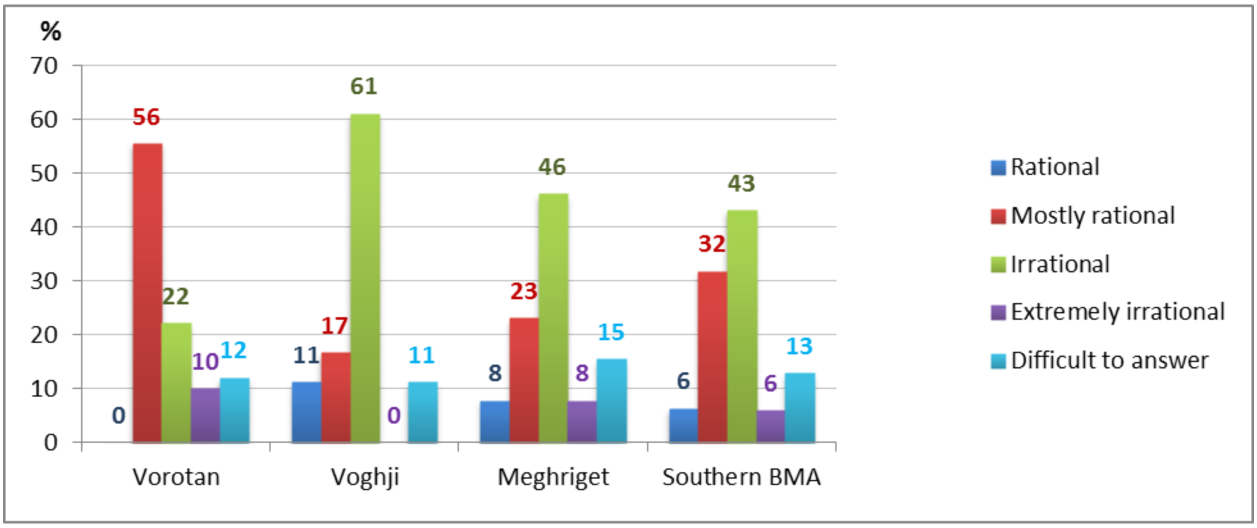


Figure 9.4: Effectiveness of water use in the Southern BMA

41% of the respondents recommended introducing water saving technologies, including drip irrigation, as a measure fostering rational water use. 34% of the respondents recommended installing water meters on drinking and irrigation pipelines, and 25% - regulating water flow through reservoir construction (Figure 9.5).

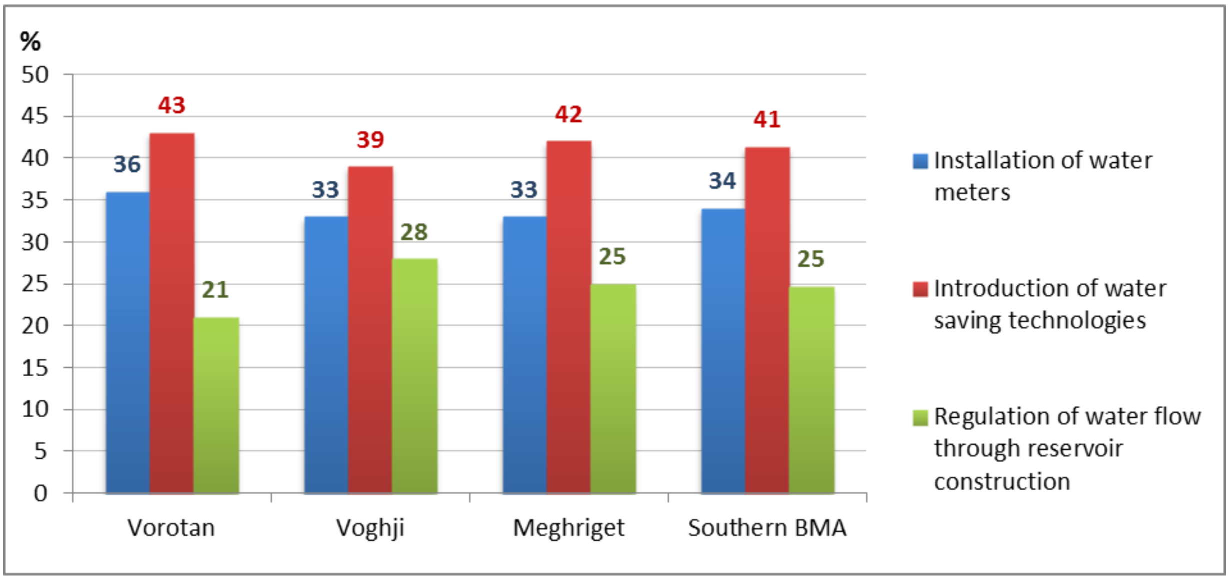


Figure 9.5: Proposed measures to promote rational water use in the Southern BMA

The respondents' answers to the question regarding prioritization of water uses in the Southern BMA were summarized as follows: (1) drinking/domestic, (2) irrigation, (3) recreation, (4) fisheries, (5) hydropower, and (6) industry.

9.5. Water Quantity

In response to the question whether there was enough drinking water in the basin, 45% of the respondents mentioned "Partly", 32% - "Yes", 20% - "No", and only 3% found it difficult to answer (Figure 9.6).

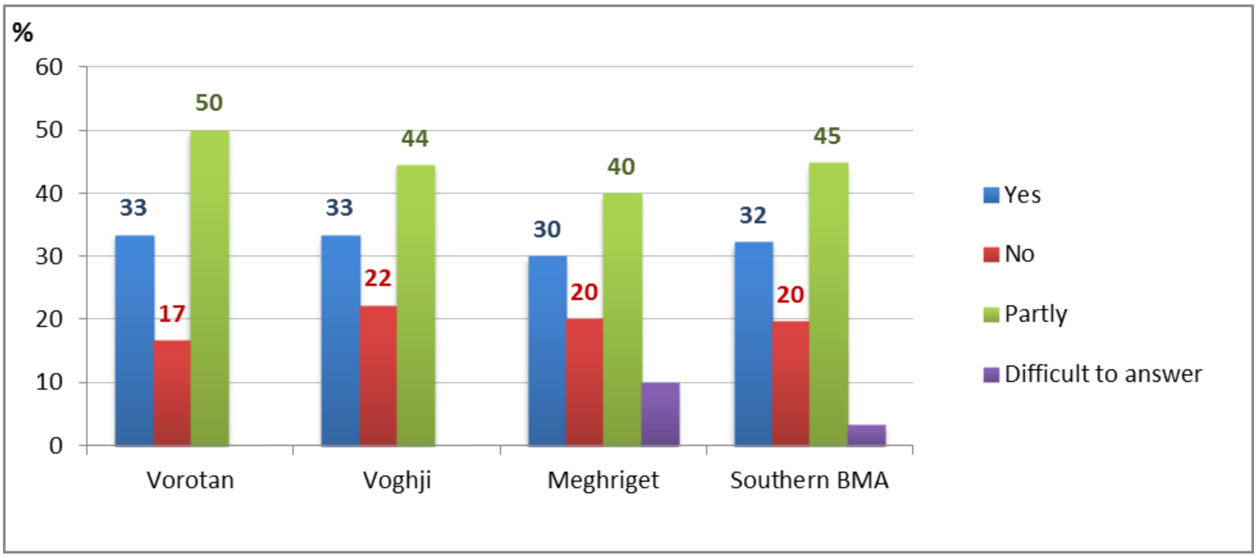


Figure 9.6: Drinking water quantity in the Southern BMA

A significant part of the respondents noted there were seasonal variations in drinking water supply in water deficit seasons – summer and autumn.

In response to the question whether there was enough irrigation water, 21% of the participants mentioned "Yes" (a high percent (38%) only in the Vorotan River Basin), 45% - "Partly", 20% - "No" (half of the respondents answered "No" in the Meghriget River Basin) and 3% found it difficult to answer (Figure 9.7).

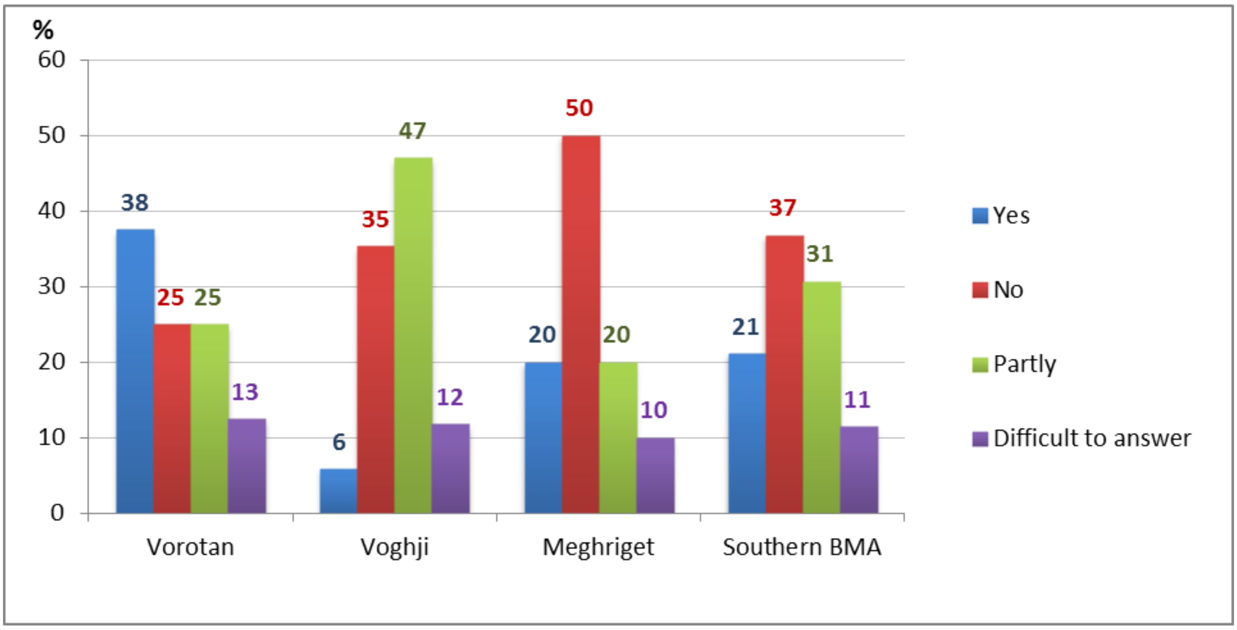


Figure 9.7: Irrigation water quantity in the Southern BMA

80% of the respondents mentioned that there were seasonal variations in irrigation water supply mainly in summer, the most intensive irrigation period in the basin.

9.6. Water Quality

The answers to the question on water quality varied in the river basins of the Southern BMA. Thus, in response to the question whether drinking water quality was satisfactory, 47% of the respondents mentioned
"Generally yes" (67% of the respondents in the Vorotan River Basin), and 33% - "No" (50% of the

respondents in the Meghriget River Basin), around 15% - “Not always”, and 2% found it difficult to answer (Figure 9.8).

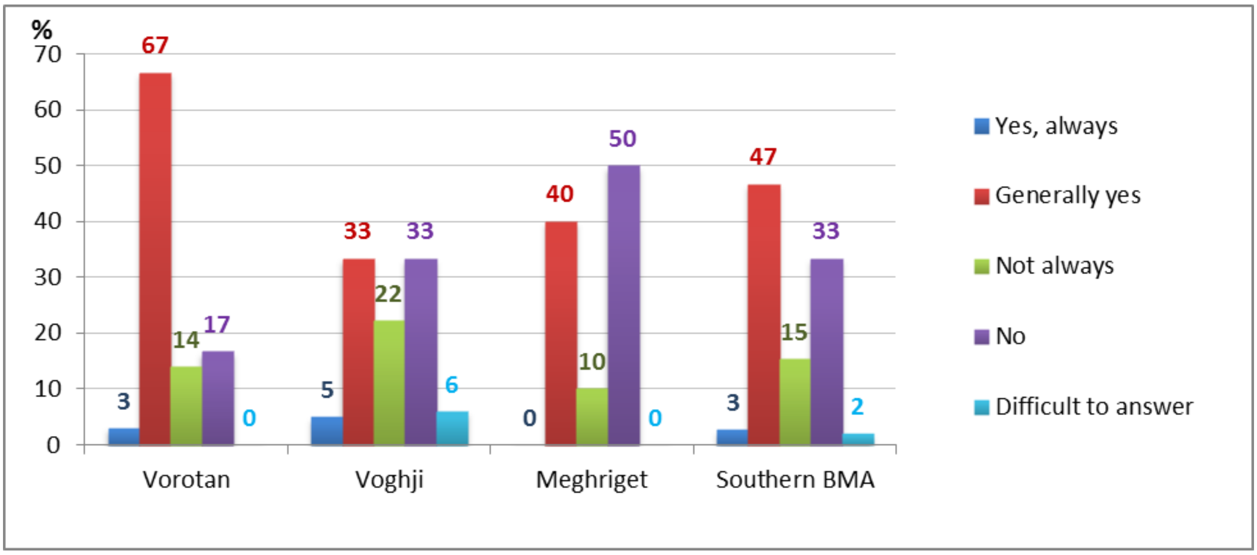


Figure 9.8: Drinking water quality in the Southern BMA

As regards the water-related diseases, almost all participants in the Voghji and Meghriget River Basins of the Southern BMA mentioned that there were water-related diseases, without specifying any specific cases. The respondents in the Vorotan River Basin believed that there were no water-related diseases in the river basin.

According to the respondents, industrial wastes (45%), wastewater (28%) and municipal wastes (20%) were the key sources of water pollution in the Southern BMA. Water resources were slightly polluted from livestock breeding (4%), and cultivation of lands (3%) (Figure 9.9).

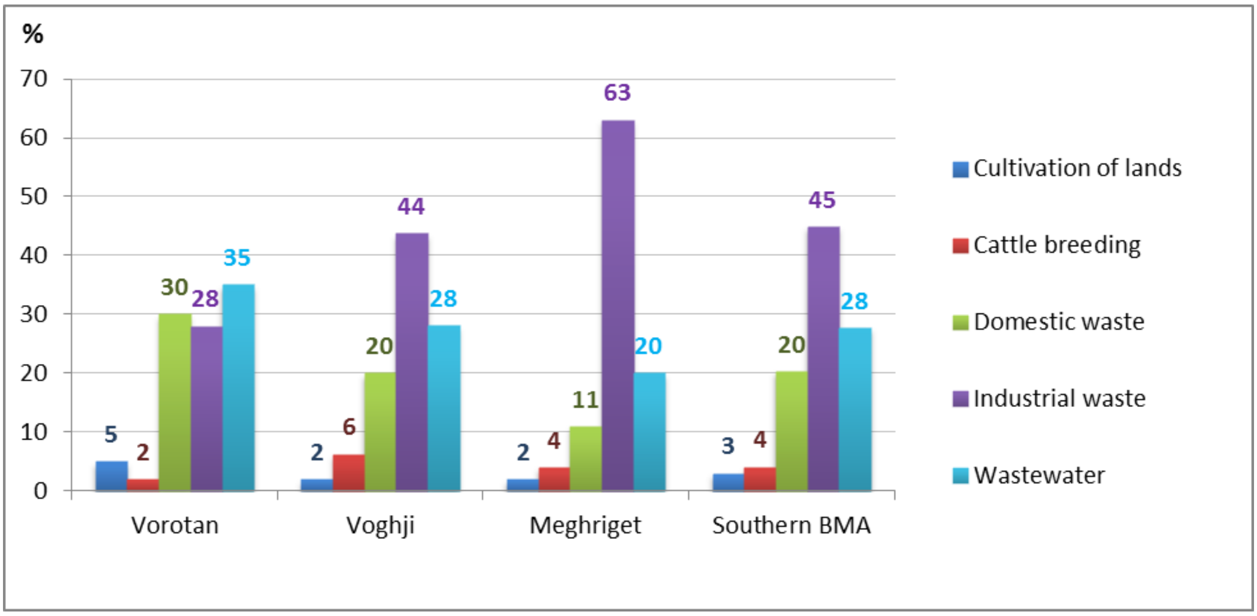


Figure 9.9: Key sources of water pollution in the Southern BMA

9.7. Public and Stakeholder Participation

The questionnaire also covered the topic of public participation in water sector. There were questions pertaining to decision making, as well as the need and approaches to more active public participation in it.

The respondents recommended decision makers to focus on the following areas: water quality - 20%, protection of water resources - 17%, regulation of water flow -16%, water quantity - 15%, promotion of rational water use - 13%, prevention of water-related disasters - 12%, and control of compliance with the terms of water use - 7% (Figure 9.10).

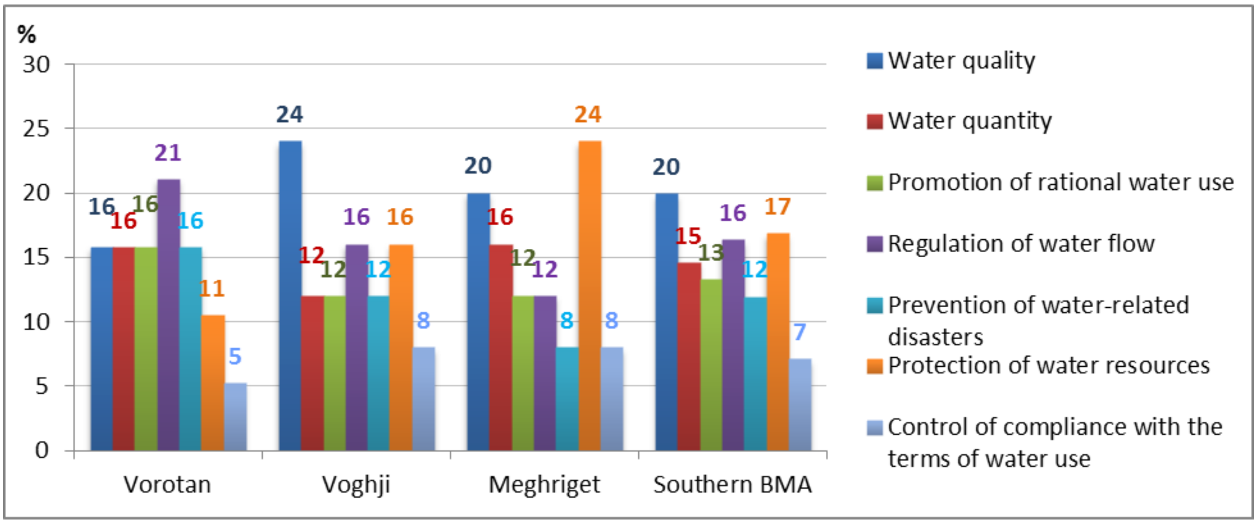


Figure 9.10: Priority areas proposed to decision makers in water sector of the Southern BMA

56% of the respondents mentioned the need for more active public participation in decision making in water sector. 15% of the respondents believed that public was already actively involved in decision making and there was no need for additional efforts. 29% found it difficult to answer to this question (Figure 9.11).

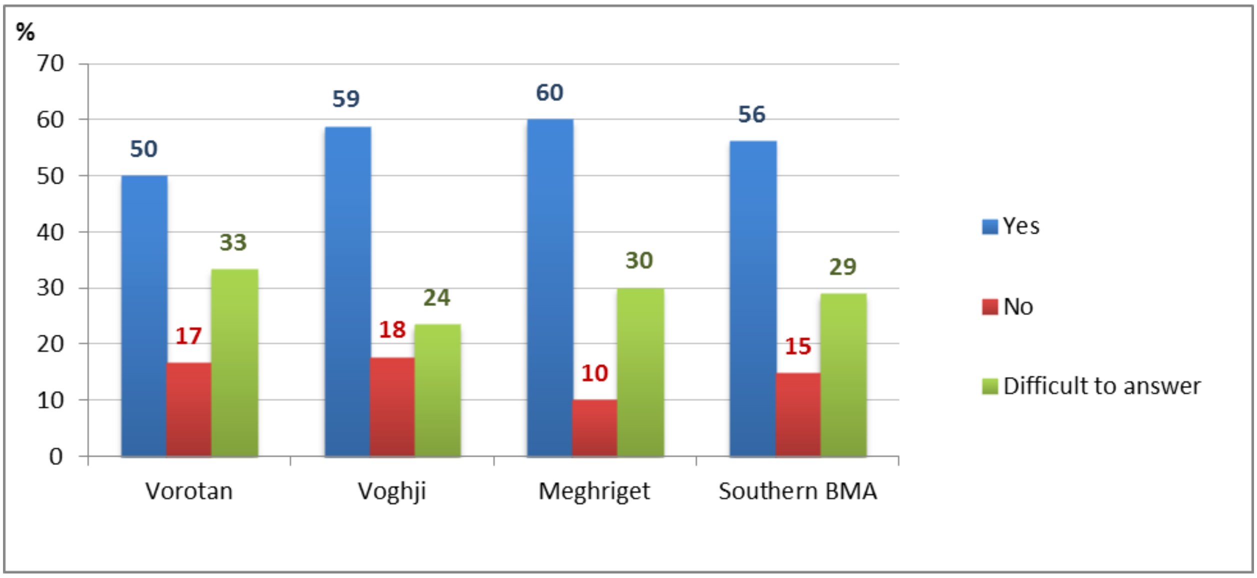


Figure 9.11: Need for more active public participation in decision making in the Southern BMA

The respondents proposed the following approaches to more active public participation in water sector of the Southern BMA: public hearings - 45%, establishment of public councils in river basins - 37%, and holding of specialized hearings - 18% (Figure 9.12).

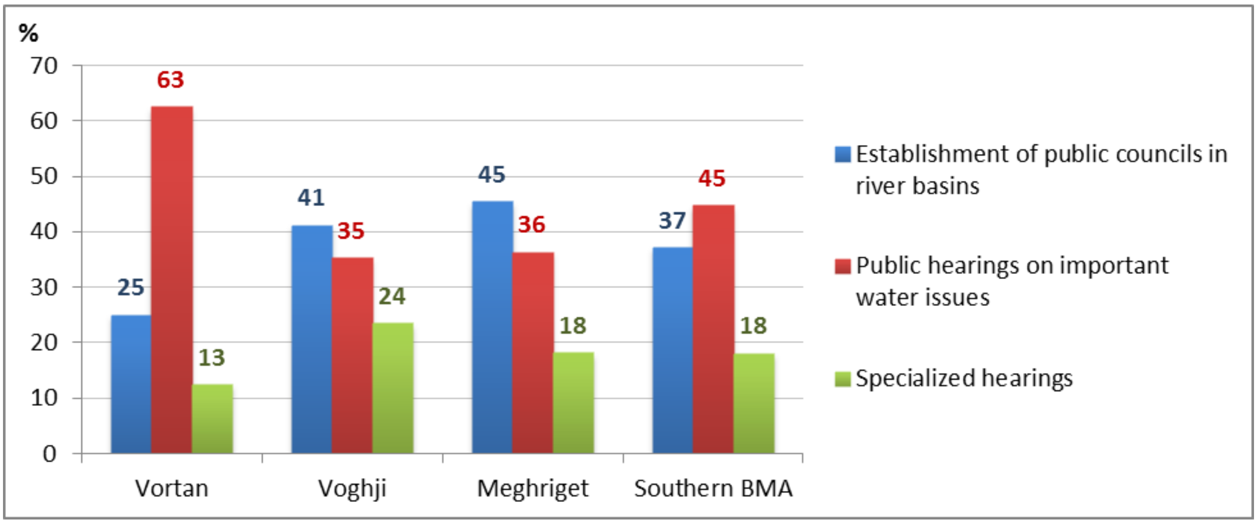


Figure 9.12: Proposed approaches to more active public participation in decision making in the Southern BMA

9.8. Conclusions and Recommendations

The findings of field studies and local stakeholder consultations show that the present issues and identified desirable status are mainly consistent with the approaches and priorities mentioned by the stakeholders in the Southern BMA. Moreover, the proposed legal, institutional and technical measures are mostly aimed at addressing the priority concerns of the affected population.

As a conclusion, public surveys and findings of the field studies, particularly all priority areas and concerns mentioned by the affected population, have been considered in development of the program of legal, institutional and technical measures to achieve desirable status in the Southern BMA.

Eight public consultations, as well as a number of working discussions and meetings were conducted in the Vorotan, Voghji and Meghriget River Basins and Yerevan during various phases of preparation of the Southern basin management plan. Comments and recommendation provided by the key government agencies and other stakeholders are incorporated in this management plan.

CHAPTER 10: ASSESSMENT OF WATER USE DEMAND IN THE SOUTHERN BASIN MANAGEMENT AREA BY SECTORS

Water use demand by various sectors in the Southern BMA was assessed on the basis of the data obtained from the RA National Statistical Service, Syunik Marzpetaran, MNP and other respective agencies.

The assessment of total water use demand, as well as water use demand by various sectors in the Southern BMA as of January 2014 – the baseline condition, was conducted based on the water use volumes defined in the WUPs issued by the RA MNP. The volumes form the water demand (data on actual water use are limited and fail to provide the details required for analysis). Economic assessment of water demand for separate sectors and the value added of use of 1m^3 of water by each sector were provided.

Economic analysis and effectiveness assessment of water use demand are conducted using cost and revenue approaches.

Cost approach is based on the fee for water use, which is defined in accordance with the RA Law on Nature Protection and Natural Resources Use Fees (1998) and RA Government Decree on Rates of Fees for Natural Resources Use (1998). It does not incorporate the total cost of water for the organizations, as the capital and operational costs for having access to the water are not accounted. The externalities and external costs for the society are not included due to absence of sufficient and reliable data for analysis and assessment.

The revenue approach is based on gross revenue generated by the water use sectors in the Southern BMA and water demand volumes as per WUPs. Consequently, the economic value (value added) generated by each water use sector in the Southern BMA as a result of use of 1m^3 water is being assessed.

In addition, this section presents the expenditures from the RA State budget made for management and protection of water resources in the Southern BMA, as of January 2014.

10.1. Analysis of Current Situation

Water use demand in the Southern BMA comprised 2647713 thousand m^3 as of January 2014. Water use demand in the Vorotan, Voghji and Meghriget River Basins comprised 73.5%, 22% and 4.5% of the total demand, respectively.

Table 10.1 presents the structure of water demand in the Southern BMA by water use sectors and river basins, as of January 2014.

Table 10.1: Water use demand in the Southern BMA by sectors as of January 2014, thousand m^3

	Hydropower generation	Fish farming	Irrigation	Mining industry	Other industry	Drinking-household	Livestock watering	Total
Vorotan River basin	1868143	17260	32481	-	265	28430	140	**1946719**
share of the total demand in the river basin	*95.96%*	*0.89%*	*1.67%*	*0.00%*	*0.01%*	*1.46%*	*0.01%*	*100%*
Voghji River basin	485831	1339	3810	65331	11	22387	0	**578710**
share of the total demand in the river basin	*83.95%*	*0.23%*	*0.66%*	*11.29%*	*0.00%*	*3.87%*	*0.0%*	*100%*
Meghriget River basin	91276	-	10442	13860	21	6686	0	**122284**
share of the total demand in the river basin	*74.64%*	*0.00%*	*8.54%*	*11.33%*	*0.02%*	*5.47%*	*0.00%*	*100%*
Southern BMA	**2445250**	**18599**	**46733**	**79191**	**297**	**54375**	**3267**	**2647713**

Source: WRMA of the RA MNP

In the same period, the value of total goods, services and works in the Southern BMA comprised about 327.5 billion AMD (in current prices), comprising about 7.2% of the RA gross domestic product.

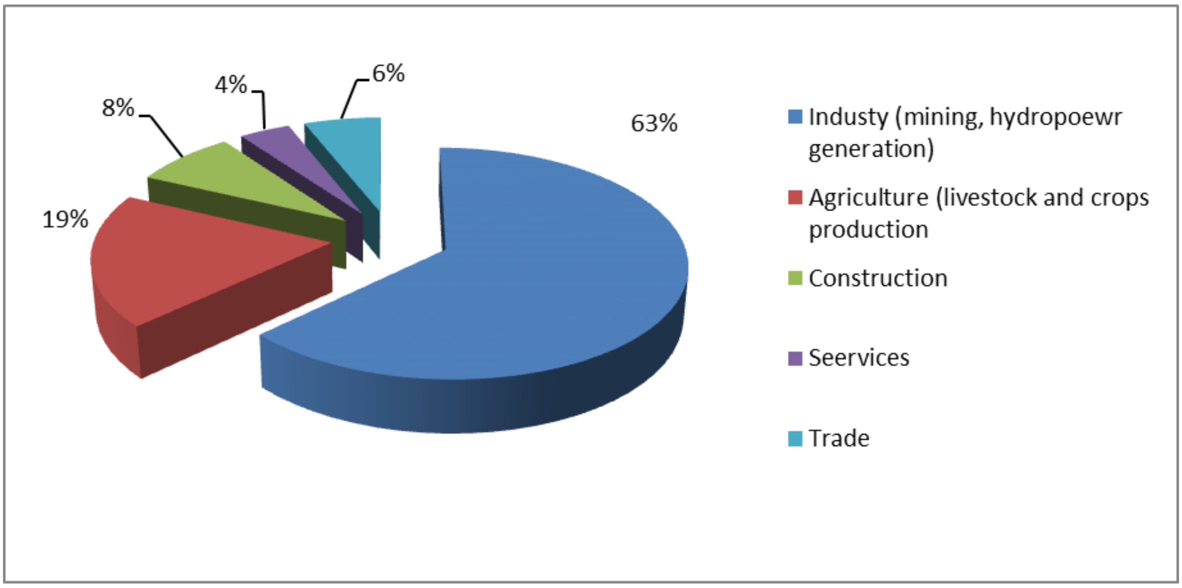


Figure 10.1: Structure of the total value produced in the Southern BMA as of January 2014
Source: The RA National Statistical Service

The results of the water use demand assessment in the Southern BMA by cost method as of 2014 are presented in Table 10.2. With the purpose of ensuring more accurate results, the share of water use volume for drinking-domestic purposes that accounts for livestock watering (calculated by head of animals by applying the effective norm) was added to the water use volume intended for livestock watering.

Table 10.2: Results of water use demand assessment by cost method in the Southern Basin, as of January 2014

	Water use source	**Hydropower generation**	**Fish farming**	**Irrigation**	**Mining industry**	**Other industry**	**Drinking-municipal**	**Livestock watering**	**Total**
Water use demand, thousand m^3									
Vorotan River Basin	Surface	1868143	13209	21057	-	227	-	-	**1893736**
	Ground	0	4050	11424	-	38	25834	2735	**52984**
Voghji River Basin	Surface	485831	1339	3810	65331	-	17752	-	**574063**
	Ground	-	-	-	-	11	4550	86	**4647**
Meghraget River Basin	Surface	91276	-	10276	-	-	3154	-	**104705**
	Ground	-	-	166	13860	21	3086	446	**17578**
Southern BMA		**2445250**	**18599**	**46733**	**79191**	**297**	**54375**	**3267**	**2647713**
Water use payment, thousand AMD									
Vorotan River basin		-	863	-	-	152	1324	270	2609
Voghji River basin		-	-	-	32665	11	671	4	33352
Meghriget River basin		-	-	-	13860	21	233	22	14136
Southern BMA		**-**	**863**	**-**	**46525**	**183**	**2229**	**296**	**50097**
Value added - AMD /1 m^3		**-**	**0.05**	**-**	**0.59**	**0.62**	**0.04**	**0.09**	

Source: State Water Cadastre of the WRMA of the RA MNP, RA Law on Nature Protection and Natural Resources Use Fees (1998) and the RA Government Decree No. 864 on Rates of Fees for Natural Resources Use (1998)

As of January 2014, water use demand in the Southern BMA assessed by cost method amounted to 50097 thousand AMD, including about 33400 thousand AMD or 66.7% - generated in the Voghji River Basin, 14100 thousand AMD or 28.2% - in the Meghriget River Basin and 2600 thousand AMD or 5.1% - in the Vorotan River basins. About 50.8% (or 1324 thousand AMD) and 33.1% (863 thousand AMD) of the total water use value estimated in the Vorotan River Basin was generated by water demand for drinking-household and fish farming, respectively. In the Voghji and Meghriget River Basins the value was generated by water demand for the mining industry, comprising 92.9% (326665 thousand AMD) and 98% (13860 thousand AMD) respectively.

The analyses show that there are significant discrepancies between water use demand (volume) and the produced economic value. For example, water use demand in the Vorotan River Basin comprises 96% of the total demand in Southern BMA, whereas the economic value accounts only 5.2% of the total water use fee in the Southern BMA. This is caused for by the rate of water use fee - the basis for calculation, which is defined 0 AMD for water use for hydropower generation.

The highest value for use of 1 m^3 of is provided by other industry, followed by the mining industry. The lowest value is provided in hydropower and irrigation sectors.

The results of assessment of water use demand in the Southern BMA for the same period using revenue method are presented in Table 10.3.

Table 10.3: Results of water use demand assessment by revenue method in the Southern BMA, as of January 2014

Water use sector	Water demand, thousand m^3	*Share in total water demand*	Income, million AMD	*Share in gross revenue*	Value added, AMD/ 1 m^3
Hydroenergy	2445250	*92.35%*	23790	*7.78%*	**1.9**
Fish breeding	18599	*0.70%*	468	*0.15%*	**0.3**
Irrigation	46733	*1.77%*	31500	*10.30%*	**33.7**
Mining industry	79191	*2.99%*	169922	*55.55%*	**2.1**
Other industry	297	*0.01%*	11263	*3.68%*	**3.8**
Drinking-domestic	54375	*2.05%*	38506	*12.59%*	**3.5**
Watering	3267	*0.12%*	30432	*9.95%*	**93.1**
Total	**2647713**	***100%***	**305881**	***100%***	

Source: State Water Cadastre of the WRMA of the RA MNP, RA National Statistical Service

As of January 2014, the maximum economic (added) value resulting from water use in the Southern Basin was provided as a result of livestock watering and irrigation, 93.1 and 33.7 AMD respectively per 1 m^3 of water used. In the hydroenergy and mining sectors, which are the largest water users in the Southern BMA, value added for used 1m^3 of water comprised respectively 1.9 AMD and 2.1 AMD.

The table below presents the comparison analysis of revenue and cost per 1m^3 of water used in the Southern BMA, as of January 2014 by applying cost and revenue methods.

Table 10.4: Comparison of the value added per 1m^3 of water used in sectors of economy in the Southern BMA

Water use sector	Revenue approach, AMD/1m^3	Cost approach, AMD/1m^3	Cost-revenue ratio, %
Hydropower generation	1.95	-	-
Fish farming	0.25	0.05	0.184
Irrigation	33.70	-	-

Water use sector	Revenue approach, AMD/1m^3	Cost approach, AMD/1m^3	Cost-revenue ratio, %
Mining industry	2.15	0.59	0.274
Other industry	3.79	0.62	0.163
Drinking-household	3.54	0.04	0.012
Livestock watering	93.14	0.09	0.001

The highest cost to revenue ratio is the highest for the mining industry, and lowest for hydropower generation and irrigation.

10.2. Costs for Basin Management

10.2.1. Introduction

The main source of finance of water resources management organizations in the Southern BMA is the RA State budget. As of January 2014, expenditures from the RA State budget for water resources management and protection in the Southern BMA amounted to 92.53 million AMD. This does not incorporate capital and program costs, as well as allocations by international donor organizations because of lack of data.

Expenditures for water resources management and protection, monitoring made in 2013 by the organizations involved in the sector are presented below.

10.2.2. Water Resources Management and Protection Organizations

Expenditures by the RA MNP, including the staff and separated subdivisions, and state-non commercial organizations as of 2014 for water resources management and protection in the Southern BMA amounted to 21.76 million AMD. The expenditure structure is presented in Table 10.5.

Table 10.5: Expenditure structure for water resources management and protection in the Southern BMA as of January 2014

Government body	*Maintenance costs*	*Labor costs*	*Coefficient for costs localization by basin or marz*	*Total cost, million AMD*
RA MNP Water Resources Policy Division	0.00	8992200.00	0.10	0.90
RA MNP WRMA	0.00	125433000.00	0.15	18.81
RA MNP Water Supervision Division of the State Environmental Inspectorate	0.00	20475000.00	0.10	2.05
Total				***21.76***

Source: RA MNP, 2015

10.2.3. Water Resources Monitoring Organizations

Expenditure made by government authorities for the purpose of surface and ground water resources quantitative and qualitative monitoring in the Southern Basin as of January 2014 amounted to 70.77 million AMD. The expenditures structure is presented in Table 10.6.

Table 10.6: Expenditure structure for conducting water resources monitoring in the Southern BMA, as of January 2014

Government body	*Maintenance costs*	*Labor costs*	*Coefficient for costs localization by basin or marz*	*Total cost, million AMD*
Hydrogeological Monitoring Center SNCO of the RA MNP	19436600.00	0.00	0.10	1.94
Environmental Impact Monitoring Center SNCO of the RA MNP	82284500.00	0.00	0.10	8.23
Armenian State Hydrometeorological and Monitoring Service SNCO of the RA MTAES	605989800.00	0.00	0.10	60.60
Total				***70.77***

Source: the RA Electronic Governance - financing of SNCOs, 2014

10.3. Summary of the Baseline Condition

Water use demand in the Southern BMA was estimated at 2647713 thousand m^3 as of January 2014, including water use for hydropower generation, and it comprised 202463 thousand m^3 without water demand for hydropower generation.

According to the data of the RA National Statistical Service, the actual water use in the Southern BMA during the same period comprised 65400 thousand m^3 (including for drinking-municipal, fish farming, agriculture and industry).

As of January 2014, the payment for the used water in the Southern BMA amounted to 27.9 million AMD, and payment for pollutants discharged into the water basin – 28.2 million AMD. Expenditures from the RA State budget for water resources management and protection, including monitoring in the Southern BMA comprised 92.53 million AMD in 2013.

CHAPTER 11: WATER RESOURCES IMPROVEMENT SCENARIO IN THE SOUTHERN BASIN MANAGEMENT AREA BY SECTORS

To provide the water resources improvement scenario in the Southern BMA by sectors, water supply and water demand based on economic development in the river basins of the basin management area for the six-year management planning (2016-2012) cycle were forecasted. Forecasted water supply was assessed taking into account economic development trends in river basins and impact of climate change on water resources. Forecasts of water demand based on economic development were made by applying different approaches to various water use sectors contingent on development peculiarities of these sectors (Annex I).

Water use forecasts are provided by two scenarios: (1) base scenario – the forecasts of sector growth rates are mainly based on target indicators defined through the economic policy; (2) optimistic scenario – additional reasonable growth rate is added to the base scenario, taking into account sector peculiarities (in case of the optimistic scenario for economic growth, water use demand increases).

Water shortage (deficit) or surplus is assessed in the river basins of the Southern BMA for the period of 2013-2015 and up to 2021, by comparing forecasted water supply and water demand in the Southern BMA.

11.1. Analysis of Current Water Supply and Development Scenarios

Water supply/availability in the Southern BMA was assessed taking into account the economic development trends in river basin and the impact of climate change on water resources. Water supply is assessed taking into consideration the values of national and strategic water reserves, usable water resources in river basins of the southern BMA that are presented in Section 1.2.5 of this management plan.

Usable water resources in the Southern BMA that are considered the main reserve for water supply formation were estimated at 115080 million m^3 as of January 2014, including:

- Natural river flow formed in the Vorotan, Voghji and Meghriget River Basins – 988.15 million m^3;
- Restorable groundwater resources – 162.65 million m^3 (the volumes of restorable groundwater resources are subject to adjustment by the RA Government).

Forecasted changes in water availability/supply in the river basins of the Southern BMA for 2016-2021 and for longer periods up to 2040, 2070 and 2100 are presented below (Table 11.1).

Table 11.1 Water supply in the Southern BMA in 2013-2021 and forecasted change till 2100

River basin	Water supply type	Water supply, million m^3											
		2013	2014	*2015*	2016	2017	2018	2019	2020	2021	2040	2070	2100
Vorotan	River flow	556.8	556.51	556.23	555.94	555.66	555.37	555.09	554.80	554.52	549.10	525.91	496.82
	Groundwater	62.10	62.07	62.04	62.00	61.97	61.94	61.91	61.88	61.85	61.24	58.65	55.41
	Total	**618.90**	**618.58**	**618.27**	**617.95**	**617.63**	**617.31**	**617.00**	**616.68**	**616.36**	**610.34**	**584.56**	**552.23**
Voghji	River flow	321.70	321.50	321.30	321.11	320.91	320.71	320.51	320.31	320.11	316.35	308.14	296.86
	Groundwater	72.2	72.19	72.18	72.17	72.16	72.15	72.15	72.14	72.13	71.95	71.58	71.06
	Total	**393.90**	**393.69**	**393.49**	**393.28**	**393.07**	**392.86**	**392.66**	**392.45**	**392.24**	**388.30**	**379.71**	**367.91**
Meghriget	River flow	109.65	109.64	109.63	109.63	109.62	109.61	109.60	109.59	109.58	109.43	109.06	108.51
	Groundwater	28.34	28.35	28.35	28.34	28.34	28.34	28.33	28.33	28.29	28.20	28.06	28.34
	Total	**138.00**	**137.99**	**137.98**	**137.97**	**137.96**	**137.95**	**137.94**	**137.93**	**137.92**	**137.72**	**137.26**	**136.57**
Total in the Southern BMA		**1150.8**	**1150.3**	**1149.7**	**1149.2**	**1148.66**	**1148.12**	**1147.6**	**1147.06**	**1146.52**	**1136.36**	**1101.53**	**1056.71**

According to Table 11.1, water supply in the Southern BMA in conditions of forecasted climate change will reduce by about 0.4% by 2021, and by about 1.3% till 2040. Thus, water supply in the water basin will reduce from 1150.8 m^3 as estimated for 2013 to 114652 million m^3 in 2021 (by approximately 4.28 million m^3) and to 1056.71 million m^3 in 2040 (by 14.44 million m^3).

One of major issues in terms of water availability/supply is accumulation of free flow in river basins. The accumulated water can be evenly distributed, to the extent possible, throughout all months of year to meet the water demand. As a result of climate change, in 2021 the expected reduction of water resources in the Southern BMA and the long-term demand growth can be settled by building new reservoirs in the basin (section 1.3). According to the concept of the perspective program for reservoir construction, with construction of projected 26 reservoirs in the Southern BMA additional capacities will be in place to store about 219.4 million m^3 of water. It will allow increasing the opportunities for regulation of water flow.

11.2. Water Demand and Water Supply Improvement Scenarios by Sectors

The analysis of water supply and water demand in the Southern BMA is presented for the base and optimistic scenarios by water use sectors. It does not include water abstraction for hydropower generation, as it is non-consumptive use, and it is impossible to distinguish demand of other sectors for using the same water.

Water supply and water demand trends in the Southern BMA till 2021 are presented by water use sectors in Tables 11.2 and 11.3, for base and optimistic scenarios respectively.

Table 11.2: Water supply and water demand ratio in the Southern BMA by sectors – 2013-2015 and until 2021, million m^3, base scenario

River basin	Water use by sectors	2013	2014	2015	2016	2017	2018	2019	2020	2021
Vorotan	*Fish farming*	*17.26*	*17.86*	*18.49*	*21.87*	*25.46*	*29.28*	*33.34*	*37.64*	*42.21*
	Irrigation	*32.48*	*33.28*	*34.10*	*34.94*	*35.80*	*36.69*	*37.59*	*38.52*	*39.47*
	Mining industry	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
	Other industry	*0.265*	*0.273*	*0.282*	*0.290*	*0.299*	*0.308*	*0.317*	*0.326*	*0.336*
	Drinking-household	*27.69*	*28.02*	*27.59*	*27.22*	*26.89*	*26.61*	*26.37*	*26.16*	*25.98*
	Livestock watering	*2.74*	*2.69*	*2.71*	*2.73*	*2.76*	*2.80*	*2.84*	*2.88*	*2.93*
	Total water demand	**80.43**	**82.13**	**83.17**	**87.06**	**91.22**	**95.69**	**100.45**	**105.53**	**110.92**
	Water availability/supply	**618.90**	**618.58**	**618.27**	**617.95**	**617.63**	**617.31**	**617.00**	**616.68**	**616.36**
	Deficit/surplus	**538.47**	**536.46**	**535.09**	**530.89**	**526.41**	**521.63**	**516.55**	**511.53**	**505.45**
Voghji	*Fish farming*	*1.34*	*1.39*	*1.43*	*2.97*	*4.61*	*6.36*	*8.23*	*10.23*	*12.35*
	Irrigation	*3.81*	*3.904*	*4.000*	*4.099*	*4.200*	*4.304*	*4.410*	*4.518*	*4.630*
	Mining industry	*65.33*	*68.64*	*72.34*	*76.51*	*80.79*	*85.32*	*90.10*	*95.16*	*100.51*
	Other industry	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*
	Drinking-household	*22.29*	*22.56*	*22.21*	*21.91*	*21.65*	*21.42*	*21.22*	*21.06*	*20.91*
	Livestock watering	*0.446*	*0.462*	*0.465*	*0.470*	*0.475*	*0.481*	*0.487*	*0.495*	*0.503*
	Total water demand	**93.23**	**96.95**	**100.42**	**105.9**	**111.63**	**117.75**	**124.28**	**131.39**	**138.64**
	Water availability/supply	**393.90**	**393.69**	**393.49**	**393.28**	**393.07**	**392.86**	**392.66**	**392.45**	**392.24**
	Deficit/surplus	**300.67**	**296.75**	**293.07**	**287.38**	**281.45**	**275.11**	**268.37**	**261.21**	**253.60**
Meghriget	*Fish farming*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
	Irrigation	*10.44*	*10.70*	*10.96*	*11.23*	*11.51*	*11.79*	*12.08*	*12.38*	*12.69*
	Mining industry	*13.86*	*15.11*	*16.48*	*17.97*	*19.60*	*21.38*	*23.31*	*25.42*	*27.72*
	Other industry	*0.021*	*0.021*	*0.022*	*0.023*	*0.023*	*0.024*	*0.025*	*0.025*	*0.026*
	Drinking-household	*4.40*	*4.45*	*4.50*	*4.56*	*4.61*	*4.67*	*4.72*	*4.78*	*4.84*
	Livestock watering	*0.086*	*0.089*	*0.090*	*0.091*	*0.092*	*0.093*	*0.094*	*0.095*	*0.097*
	Total water demand	**28.81**	**30.39**	**31.96**	**33.68**	**35.54**	**37.57**	**39.78**	**42.17**	**44.76**
	Water availability/supply	**138.00**	**137.99**	**137.98**	**137.97**	**137.96**	**137.95**	**137.94**	**137.93**	**137.92**
	Deficit/surplus	**109.19**	**107.60**	**106.02**	**104.29**	**102.42**	**100.38**	**98.16**	**95.76**	**93.15**
Southern BMA	*Fish farming*	18.60	19.25	19.92	24.84	30.08	35.65	41.57	47.87	54.56
	Irrigation	*46.73*	*47.89*	*49.07*	*50.28*	*51.51*	*52.78*	*54.09*	*55.42*	*56.78*
	Mining industry	*79.19*	*83.76*	*88.82*	*94.48*	*100.39*	*106.69*	*113.41*	*120.58*	*128.23*
	Other industry	*0.297*	*0.306*	*0.315*	*0.325*	*0.334*	*0.344*	*0.355*	*0.365*	*0.376*
	Drinking-household	*54.38*	*55.03*	*54.18*	*53.45*	*52.81*	*52.25*	*51.78*	*51.36*	*51.01*
	Livestock watering	*3.267*	*3.237*	*3.262*	*3.292*	*3.329*	*3.370*	*3.417*	*3.469*	*3.525*
	Total water demand	**202.46**	**209.47**	**215.55**	**226.63**	**238.37**	**251.01**	**264.52**	**278.93**	**294.32**
	Water availability/supply	**1150.8**	**1150.3**	**1149.7**	**1149.2**	**1148.7**	**1148.1**	**1147.6**	**1147.1**	**1146.5**
	Deficit/surplus	**948.34**	**940.83**	**934.15**	**922.57**	**910.33**	**897.09**	**883.08**	**868.17**	**852.18**

Irrigation: About 7487 ha was irrigated in the Southern BMA in 2013 out of total 16217 ha irrigated land. The annual water abstraction for irrigation purposes in the Southern BMA in the same period comprised 46.7 million m^3. In case of annual 3.5% growth of irrigated lands in the Southern BMA – base scenario, irrigated lands in the Southern BMA by 2021 will comprise 9859 ha, and water abstraction for irrigation purposes will amount to 56.8 million m^3 (Table 11.2).

Water abstraction for drinking-municipal purposes: To forecast water extraction for drinking-municipal purposes in the Southern BMA, the population growth trends in the basin were taken as a basis. As of January 2014, water abstraction for drinking-household purposes in the Southern BMA comprised 54.4 million m^3. According to base scenario, water abstraction in 2021 for drinking-household will increase by approximately 6.2%, and comprise about 51.0 million m^3 (Table 11.2). Small increase rate of water abstraction for drinking-household use in the Southern BMA is a result of low population growth rates, as well as improvements in the water supply network.

Industry: As of January 2014, water abstraction in the Southern BMA for industry purposes was 79.5 million m^3. According to base scenario, water abstraction for use in industry by 2021 will increase by approximately 62%, and comprise about 128.6 million m^3 (Table 11.2). The forecasted increase of water abstraction volumes is expected due to development of mining industry in the Voghji and Meghriget River Basins.

Hydropower generation: Water abstraction for hydropower generation comprised 2445250 million m^3 as of January 2014. Taking into consideration development trends of the SHPPs till 2021, according to base scenario, water use in the Southern BMA for hydropower generation will comprise 3592181 million m^3. Water supply in the same period is forecasted at 1146520 million m^3. The difference between the forecasted water demand for hydropower generation and water supply/availability in the southern BMA is explained by use of water by other sectors after the hydropower generation.

Forecasted growth of water use for hydropower generation by up to 46% until 2021 may result in failure of maintaining the ecological flow in the rivers under decreasing volumes of river flow in the same period under conditions of climate change.

Fish farming: Fish farming in the Southern BMA is presented by scenarios for the Vorotan and Meghriget River basins. According to these scenarios, water use for fish farming by 2021 is expected to increase by about 3 times as compared to 2013, comprising 18.6 million m^3 in 2021 in comparison with 54.6 million m^3 (Table 11.2).

Comparison of forecasted water supply/availability and water demand in the river basins in case of optimistic scenario of economic growth in the Southern BMA is presented below (Table 11.3).

Table 11.3: Comparison of water supply and water demand in the Southern BMA by sector, 2013-2015 and up to 2021, million m^3, optimistic scenario

River basin		2013	2014	2015	2016	2017	2018	2019	2020	2021
Vorotan	Water demand	*98.7*	*103.4*	*106.8*	*111.6*	*116.0*	*120.6*	*125.5*	*130.3*	*135.4*
	Water supply	*618.9*	*618.6*	*618.3*	*617.9*	*617.6*	*617.3*	*617.0*	*616.7*	*616.4*
	Deficit/surplus	**520.2**	**515.1**	**511.4**	**506.4**	**501.7**	**496.7**	**491.5**	**486.3**	**480.9**
Voghji	Water demand	*116.1*	*125.5*	*135.2*	*145.8*	*157.3*	*169.8*	*183.6*	*198.6*	*215.1*
	Water supply	*393.9*	*393.7*	*393.5*	*393.3*	*393.1*	*392.9*	*392.7*	*392.4*	*392.2*
	Deficit/surplus	**277.8**	**268.2**	**258.3**	**247.5**	**235.8**	**223.1**	**209.1**	**193.9**	**177.1**
Meghriget	Water demand	*33.6*	*36.6*	*39.8*	*43.3*	*47.5*	*52.0*	*57.0*	*62.7*	*69.1*
	Water supply	*138.0*	*138.0*	*138.0*	*138.0*	*138.0*	*137.9*	*137.9*	*137.9*	*137.9*
	Deficit/surplus	**104.4**	**101.4**	**98.2**	**94.7**	**90.4**	**86.0**	**80.9**	**75.2**	**68.8**
Southern BMA	Water demand	*202.5*	*209.5*	*281.8*	*300.7*	*320.8*	*342.4*	*366.2*	*391.6*	*419.7*
	Water supply	**1150.8**	**1150.3**	**1149.7**	**1149.2**	**1148.7**	**1148.1**	**1147.6**	**1147.1**	**1146.5**
	Deficit/surplus	**948.3**	**940.8**	**868.0**	**848.5**	**827.9**	**805.7**	**781.4**	**755.4**	**726.8**

Analysis of water supply and water demand shows that water demand will increase by approximately 45% - in the Southern BMA by 2021 by base scenario, and will comprise 294.32 million m^3 versus 202.5 million m^3 as of January 2014. In case of optimistic scenario the demand will grow by approximately 107% - comprising 419.7 million m^3 versus 202.5 million m^3 as of January 2014. Water abstraction for hydropower generation is not considered in the analysis, as this water is also used by other sectors and accounted for respectively in the sectoral demand.

It would be possible to meet water use demand in conditions of economic development and mitigate possible impacts on water supply/availability both by base and optimistic scenarios if measures proposed in the management plan for achieving the environmental objectives are implemented in the Southern BMA.

CHAPTER 12: ASSESSMENT OF FINANCIAL DEFICIT IN THE SOUTHERN BASIN

Data received from the following sources was used for identification of the financial deficit in the Southern BMA: the RA Syunik Marz Social-Economic Development Program for 2010-2013, Monitoring and Evaluation Report on Implementation of the Annual Work Plan for 2013 of the RA Syunik Marz Social-Economic Development Program for 2010-2013 approved by the RA Government Decisions No. 782-N, dated June 26, 2102; data provided by the RA National Statistical Service and the RA MNP on payments for use of water resources and pollution of water resources in the Southern BMA, as well as allocations from the RA State budget to the state authorities and their regional sub-divisions that are responsible for water resources management and protection in the Southern basin.

12.1. Identification of the Financial Deficit

Capital and other costs: capital and other costs made for management and protection of water resources in the Southern basin management area for 2013, according to Monitoring and Evaluation Report on Implementation of the Annual Work Plan for 2013 of the RA Syunik Marz Social-Economic Development Program for 2010-2013, are presented below (Table 12.1)

Table 12.1: Capital and other costs related to the water sector management in the Southern Basin, 2013

Name of measure	Size of financing, as of 31.12.2013. million AMD	Source of Finance
Urban development		
Construction of internal sewerage network and internal water pipeline in the Tatev village	18.939	Rotary Club of Yeravan NGO
Infrastructures		
Implementation of measures for protecting the Araks River banks	26.48	RA State budget
Cleaning of the Kavart river bed in the Kapan town, cleaning of the flood channels within the Verishen and Brnakot communities	102.890	RA State budget
Water supply and wastewater disposal		
Rehabilitation of water canal in the Lichk village	0.5	Zangezur Copper-Molybdenum Combine CJSC
Capital renovation of the Kajaran town drinking water treatment plant	29.4	Zangezur Copper-Molybdenum Combine CJSC
Construction of water pipeline for the Military Unit N	3.47	Zangezur Copper-Molybdenum Combine CJSC
Replacement of asbestos-cement section of the external water supply pipeline in the Lichk village with metal-plastic pipes	11.0	Zangezur Copper-Molybdenum Combine CJSC
Capital renovation of water supply networks in the Agarak and Yeghvard villages	17.8	World Vision International
Capital renovation of water pipeline in the Nor Astghaberd village	0.17	Community budget
Capital renovation of water supply and sewerage networks in the towns of Kapan, Goris, Sisian, Agarak and Meghri and Vardanidzor village	27.0	Armenian Water and Sewerage Company CJSC
Agriculture		
Capital renovation of the irrigation systems	123.0	RA State budget
Design of improving the irrigation system for Arashen village	0.35	Dundee Precious Metals Company CJSC
Nature protection*		

Name of measure	Size of financing, as of 31.12.2013. million AMD	Source of Finance
Implementation of social-economic and environmental projects in the Syunik Marz villages and specially protected natural areas	8.89	RA State budget
	5.37	Community budget
	7.73	International donor organizations
Total:	**383.257**	

* The environmental projects with total of 219.9 million AMD cost were implemented in 2013 the Southern Basin. According to expert assessment, 10% of this amount was related to water resources.

According the Monitoring and Evaluation Report on Implementation of the Annual Work Plan for 2013 of the RA Syunik Marz Social-Economic Development Program for 2010-2013, capital and other cost with total amount of **383.26 million** AMD were made in the Southern BMA for water sector management. Allocations from the RA State budget comprised **261.53 million AMD**, community budget – **5.54 million AMD,** private investors - **44.72 million AMD.** Funds allocated by international donor organizations and other sources made **44.47 million AMD.** Investments by the Armenian Water and Sewerage Company made **27.0 million AMD.**

Investment costs for implementing the technical measures, including those aiming at prevention of emergency situations and reduction of their hazards, as provided for in the Southern Basin Management Plan, are estimated at **100654.9 million AMD** (Chapter 8). Recommended sources of finance for capital and other costs are: the RA State budget, other sources of finance that are not prohibited by RA legislation- **6309.60 million AMD**; community budget – **1290.75 million AMD**; international donor organizations or other sources – **84838.30 million AMD**; private investors – **944.92 million AMD**; water supply organizations - **7271.39 million AMD**.

The preliminary cost for implementing priority measures identified by the key stakeholder authorities in the Southern BMA during 2016-2021 is estimated at 68547.38 million AMD, to be covered from the following sources: the RA State budget, other sources of finance not prohibited by RA legislation – about 6795.2 million AMD; international donor organizations or other foundations – about 60807.16 million AMD; private sector (mining enterprises) – 945 million AMD.

12.2. Financial Flows and Deficit in Water Resources Management and Protection Sector

According to data of the RA National Statistical Service, the total payment for water use in the Southern BMA comprised 27.9 million AMD. According to the same source, the amount paid for discharging hazardous materials into the water basins comprised 28.2 million AMD.

According to the RA MNP data, the total amount generated as a result of receiving compensation for damages incurred to the water resources in the Southern BMA comprised about 0.47 million AMD in 2013, while other penalties and fines made 4.6 million AMD.

In 2013, the expenditure from the RA State budget for water resources management and protection in the Southern BMA totaled 92.53 million AMD (Tables 10.5 and 10.6). According to the Monitoring and Evaluation Report on Implementation of the Annual Work Plan for 2013 of the RA Syunik Marz Social-Economic Development Program for 2010-2013, allocations from the RA State budget for capital and other costs in the water sector in the Southern BMA comprised about 261.53 million AMD.

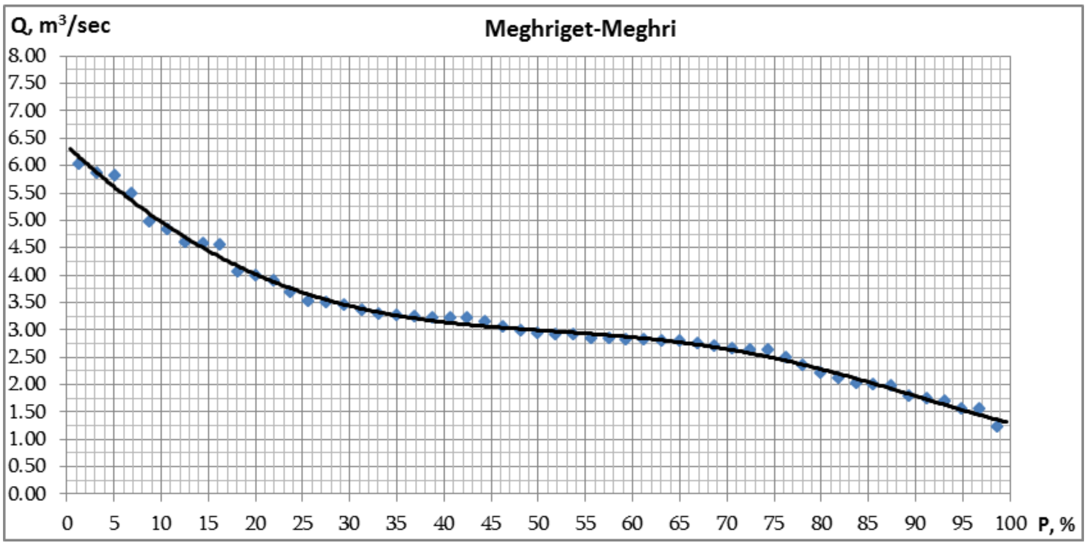
12.3. Opportunities and the Potential for Additional Funding

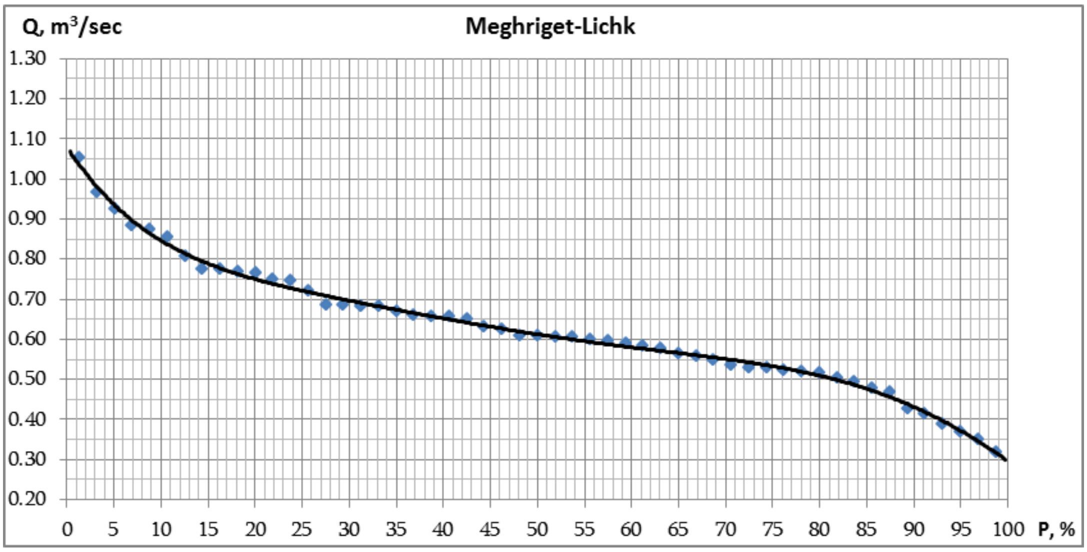
The financing required for implementation of the priority legal, institutional, technical measures, including those addressing climate change adaptability and prevention of potential emergency situations and reduction of the possible hazards thereof, as well as implementation of the new surface and ground water monitoring program over the first 6-year management cycle (2016-2121) to achieve desirable status in the Southern BMA is estimated at 68563.16 million AMD. Allocations from the RA State budget, other sources of finance not prohibited by RA legislation are estimated at 6806.2 million AMD. The major part of investments required is to be covered by grants, loans and other types of allocation from international donor organizations. This is due to financial deficit as a result of the financial and economic crisis.

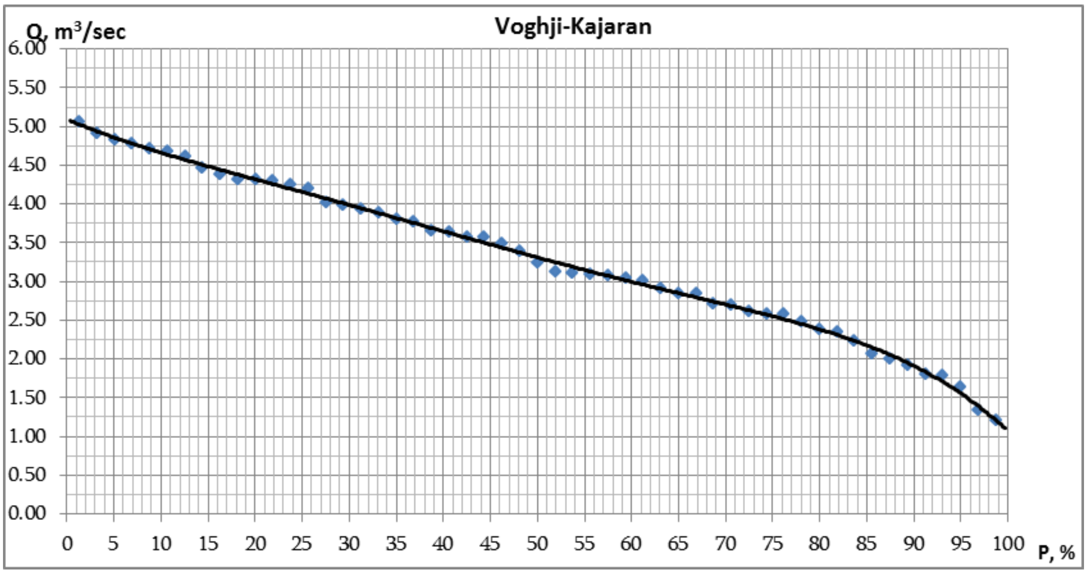
Measures proposed for covering the deficit in finance required for implementation of the Program of Measures are as follow:

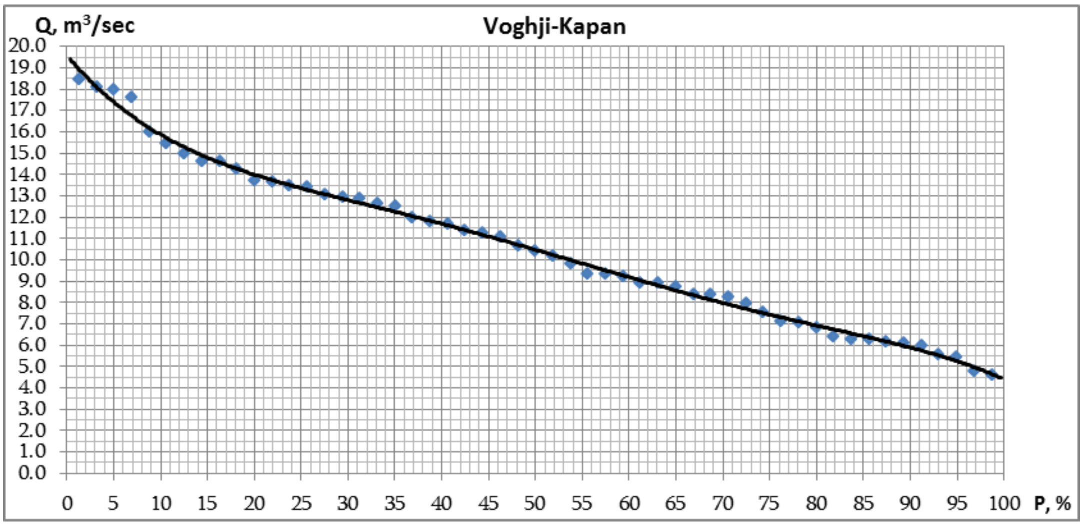
- Cooperation with international donor organizations, other local and foreign foundations for providing resources (grants, loans, other allocations) for funding the priority measures proposed in the management plan. Particularly, continue cooperation with USAID, EU, UNDP, Organization for Economic Cooperation and Development (OECD), Organization for Security and Cooperation in Europe (OSCE), etc. in ensuring grants and other resources for financing implementation of legal and institutional and technical measures proposed in the management plan. Continue cooperation with the Asian Development Bank (ADB), European Bank for Reconstruction and Development (EBRD) and other finance institutions for ensuring loans from implementation of the technical measures.
- Cooperation with private investors to target resources within their social corporate responsibility for financing implementation of measures defined in the management plan. Particularly, cooperate with mining enterprises present in the Southern BMA for funding investments required for construction of wastewater treatment facilities in the villages of the Southern BMA, including those included in the agglomerations, and other measures.
- Increase financial flows into the RA State budget at the expense of fees for water use and pollution of water resources, amounts paid to compensate for damages incurred to water resources, through revising, as appropriate, rates of the fees for use of natural resources and pollution of the environment, and improving environmental supervision.
- Increasing allocation of financial resources to the affected communities in accordance with the RA Law on Targeted Use of Environmental Payments made by companies with the purpose of financing the implementation of respective measures, as well as earmarking the funds generated from payments made for use of natural resources;
- Ensuring financing of respective measures in compliance with the requirements of the RA Government Decree No. 1079-N, adopted in 2012 on approving the procedure of using the capital fund for nature and environmental protection and its sizes, composition of the professional committee, as well as considering null and void the Government Decree No. 1128-N, as of August 14. 2003";
- Ensuring allocation of resources to fund implementation of respective measures proposed in this management plan, following the adoption of the RA Law on Ecosystem Services and implementation mechanisms thereof, as it is required by the Program of Measures to achieve the objectives deriving from the concept on creation of innovative financial-economic mechanisms for environmental sector, referred to in the annex to the RA Government Protocol Decree No. 47, dated November 14, 2013.

Annex A. Curves of River Dicharge in the Southern BMA and Values of Occurence








Q, m³/sec
Voghji-Kapan
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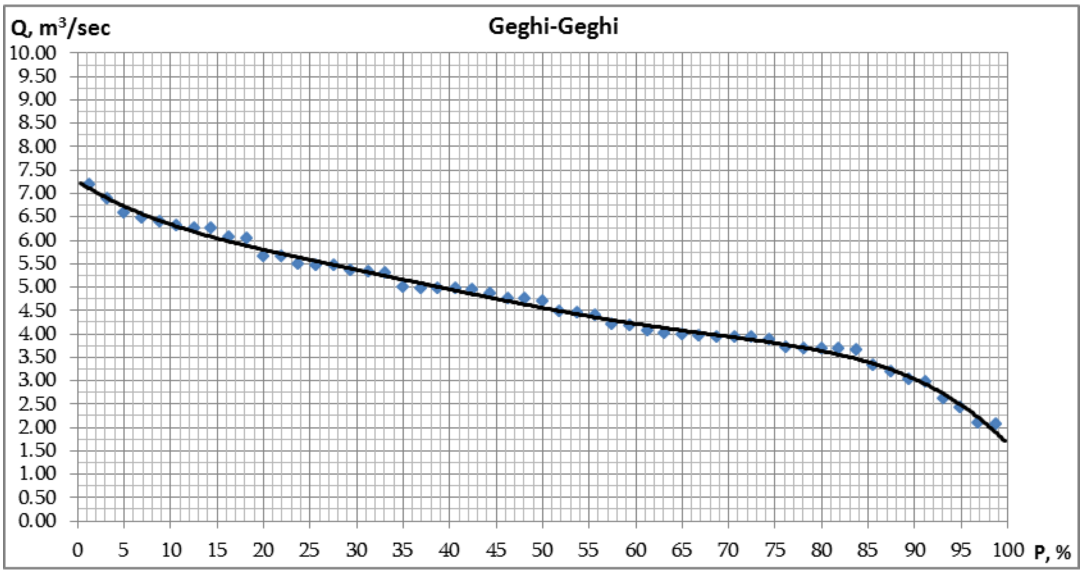
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
P, %


Q, m³/sec
Geghi-Geghi
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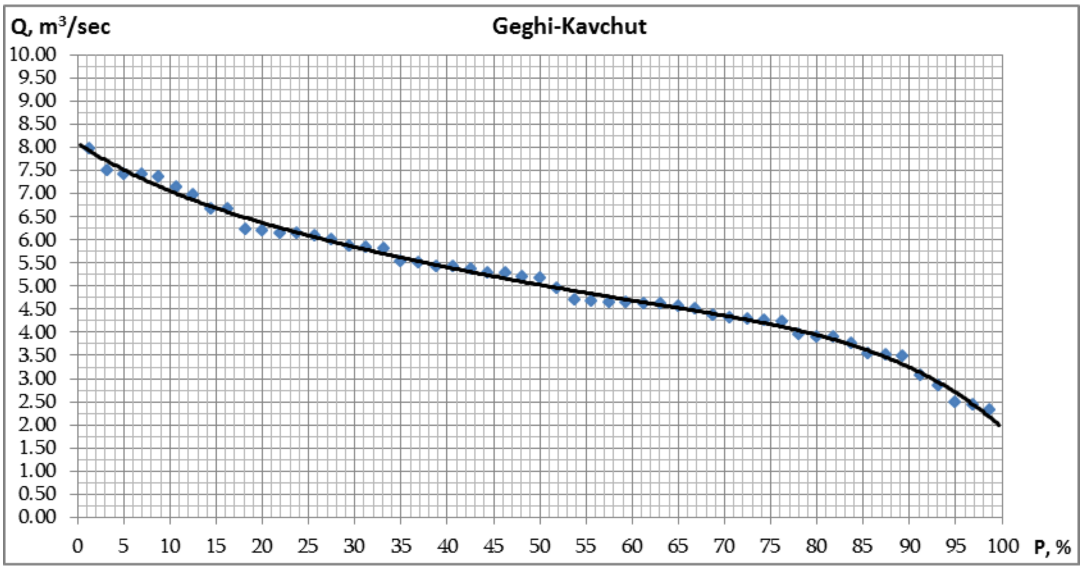
9.50
9.00
8.50
8.00
7.50
7.00
6.50
6.00
5.50
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
P, %


Q, m³/sec
Geghi-Kavchut
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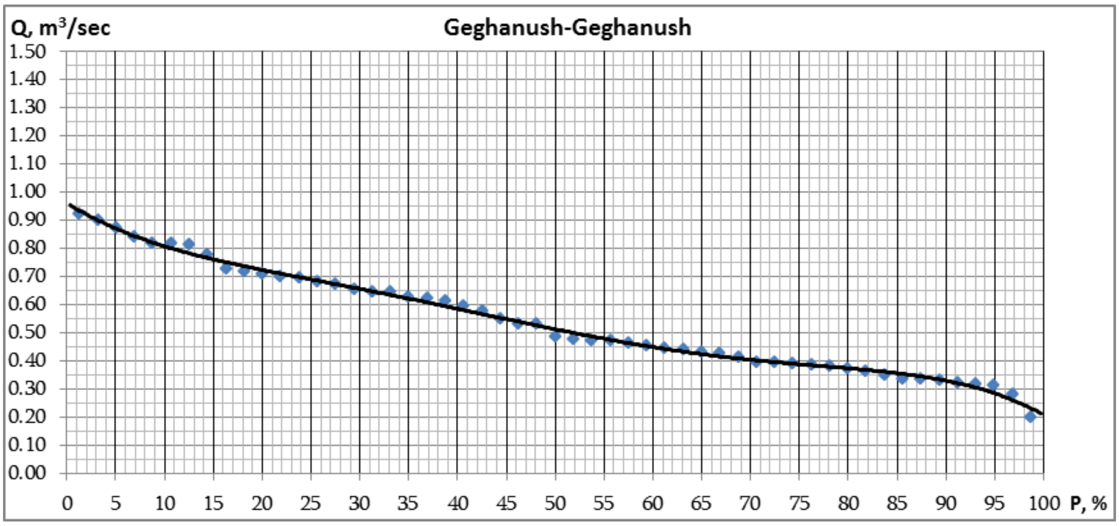
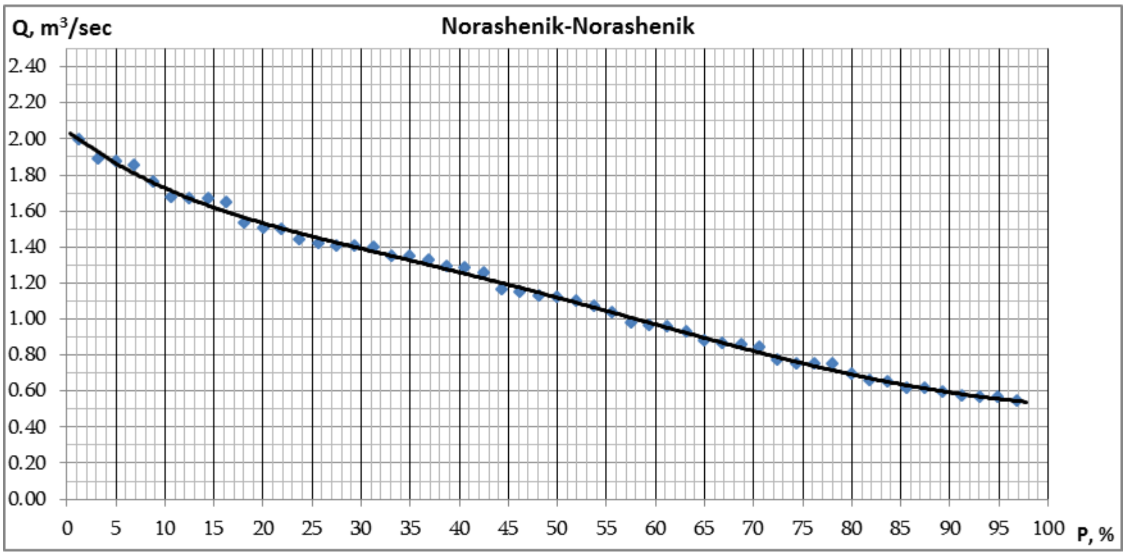
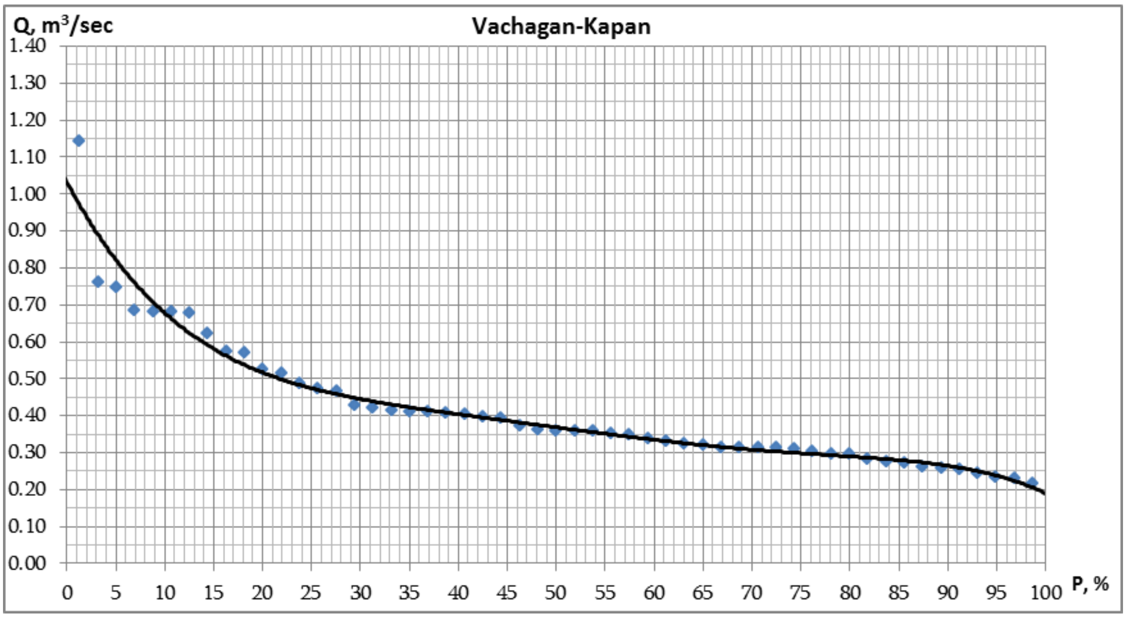
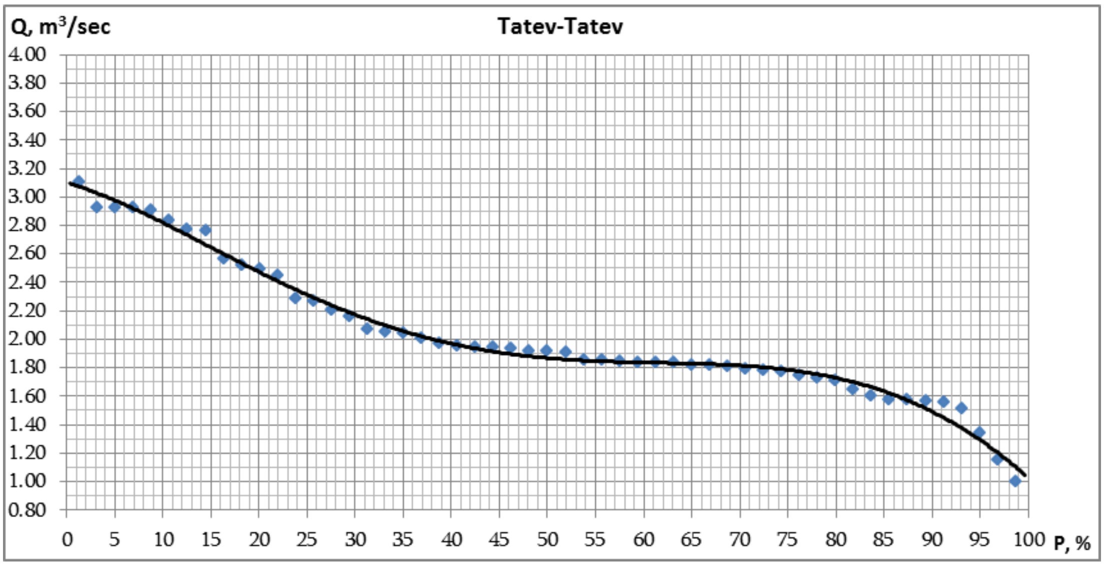
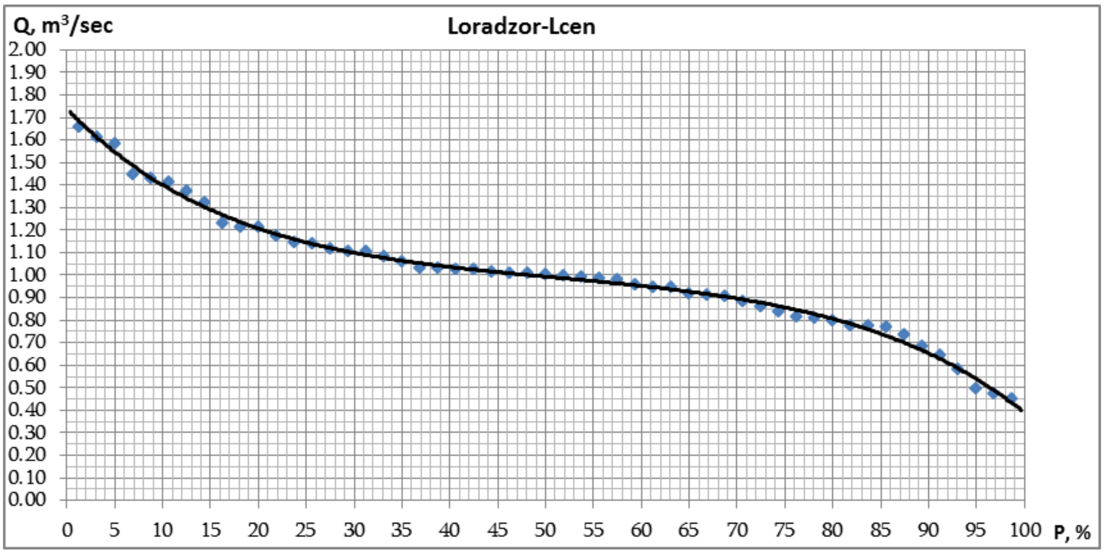
9.50
9.00
8.50
8.00
7.50
7.00
6.50
6.00
5.50
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
P, %

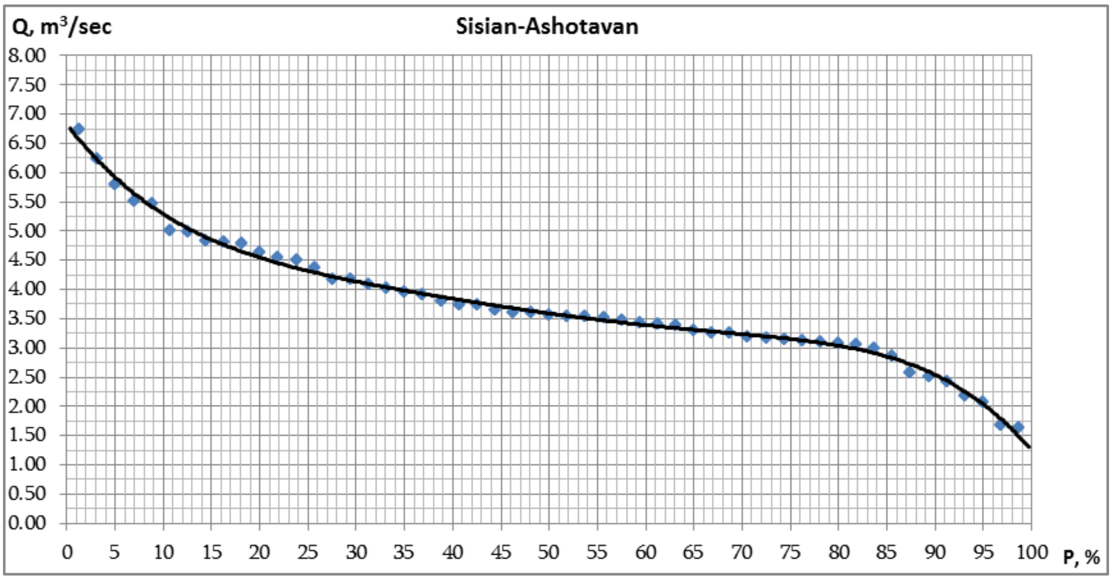

Q, m³/sec
Geghanush-Geghanush
P, %

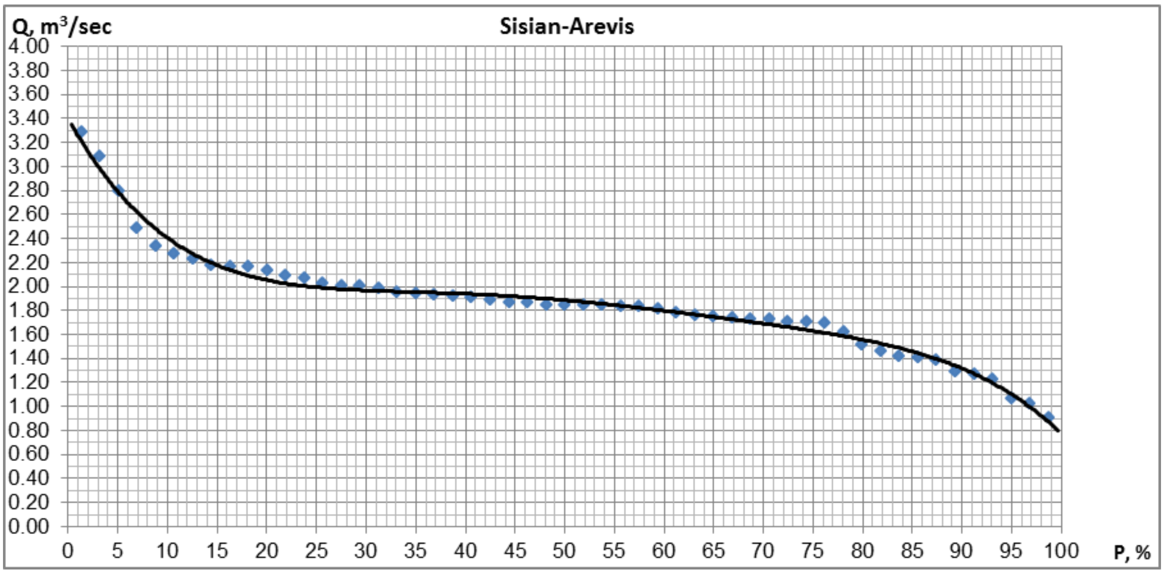

Q, m³/sec
Norashenik-Norashenik
P, %

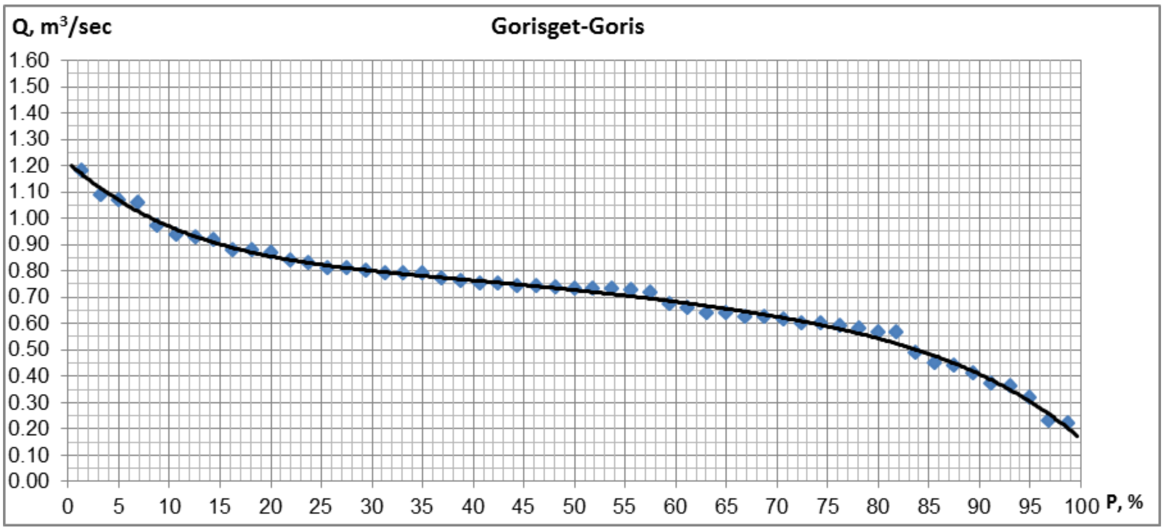

Q, m³/sec
Vachagan-Kapan
P, %

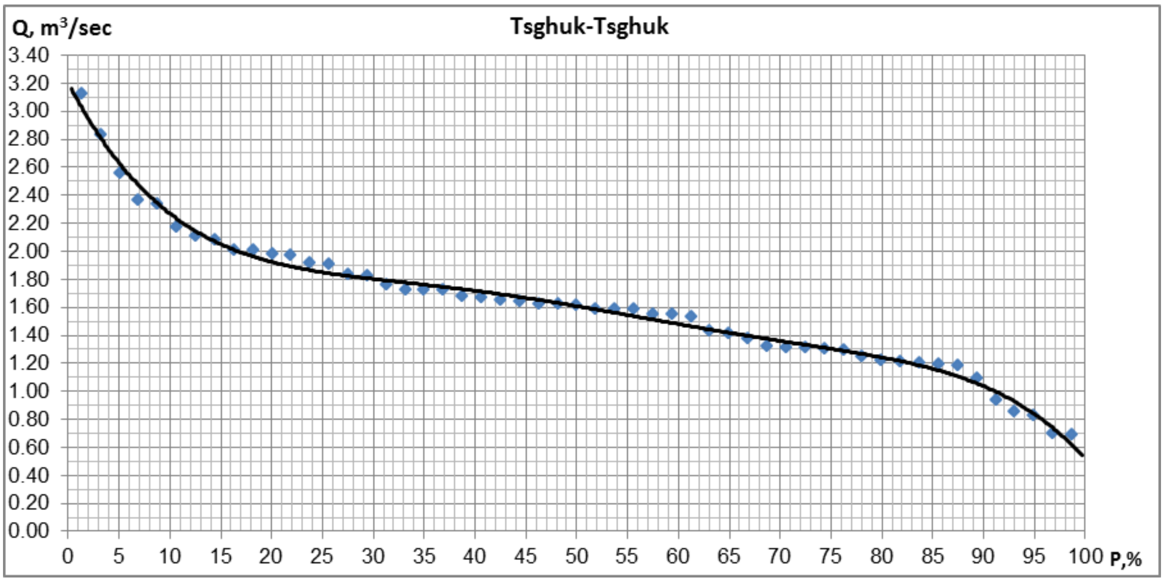

Q, m³/sec
Tatev-Tatev
4.00
3.80
3.60
3.40
3.20
3.00
2.80
2.60
2.40
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
P, %

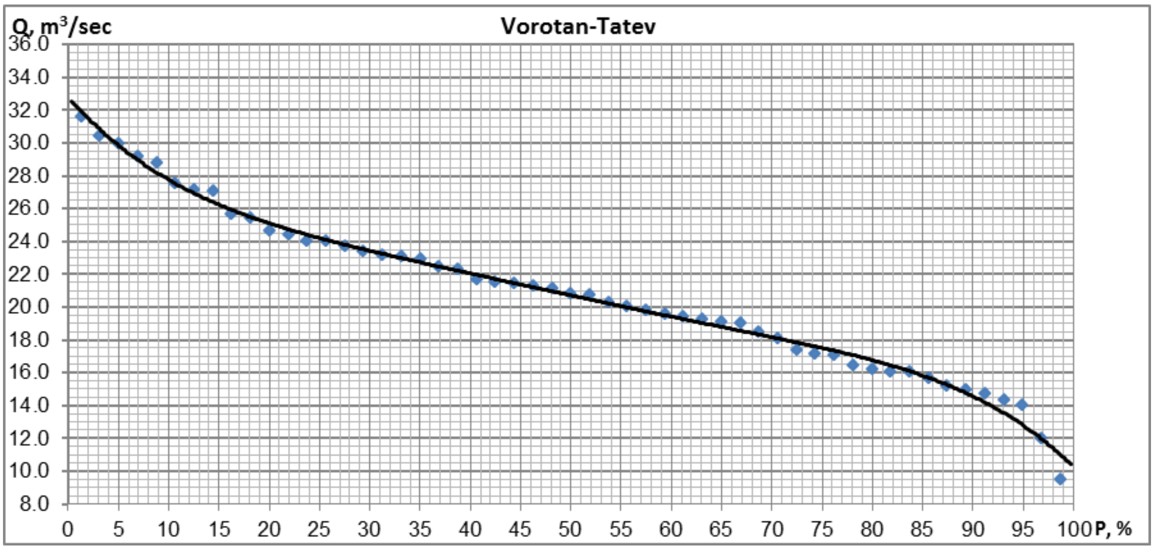

Q, m³/sec
Loradzor-Lcen
2.00
1.90
1.80
1.70
1.60
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
P, %

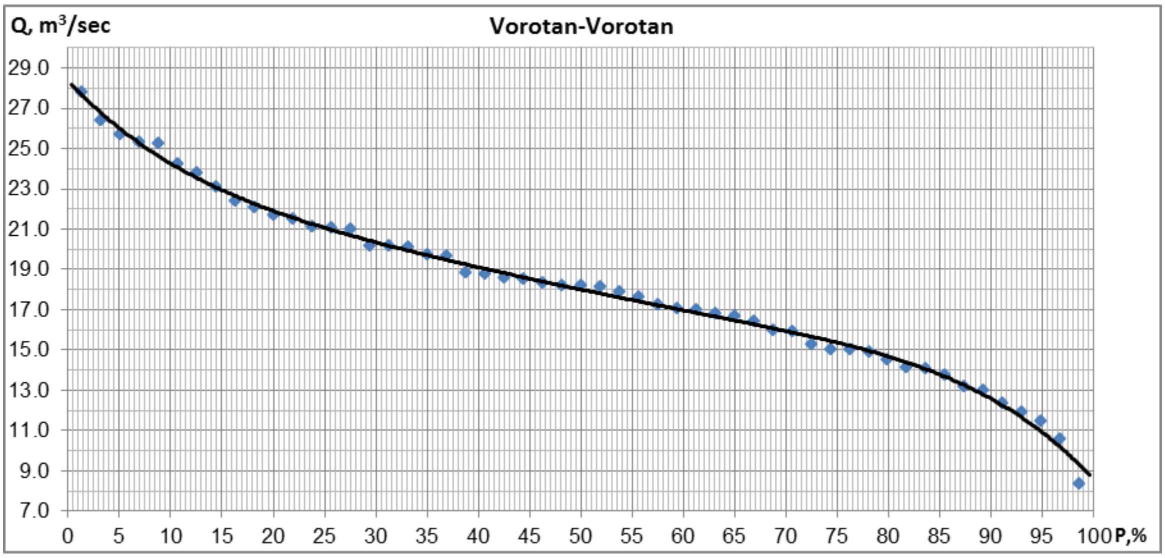

Q, m³/sec
Sisian-Ashotavan
8.00
7.50
7.00
6.50
6.00
5.50
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
P, %

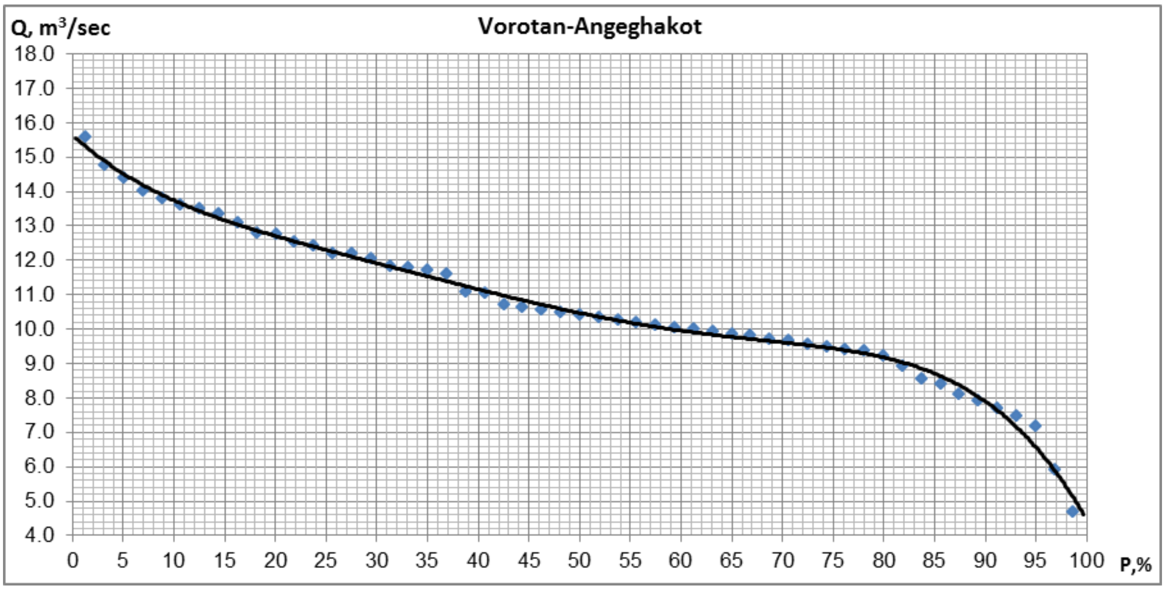

Q, m^3/sec
Sisian-Arevis
4.00
3.80
3.60
3.40
3.20
3.00
2.80
2.60
2.40
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
P, %

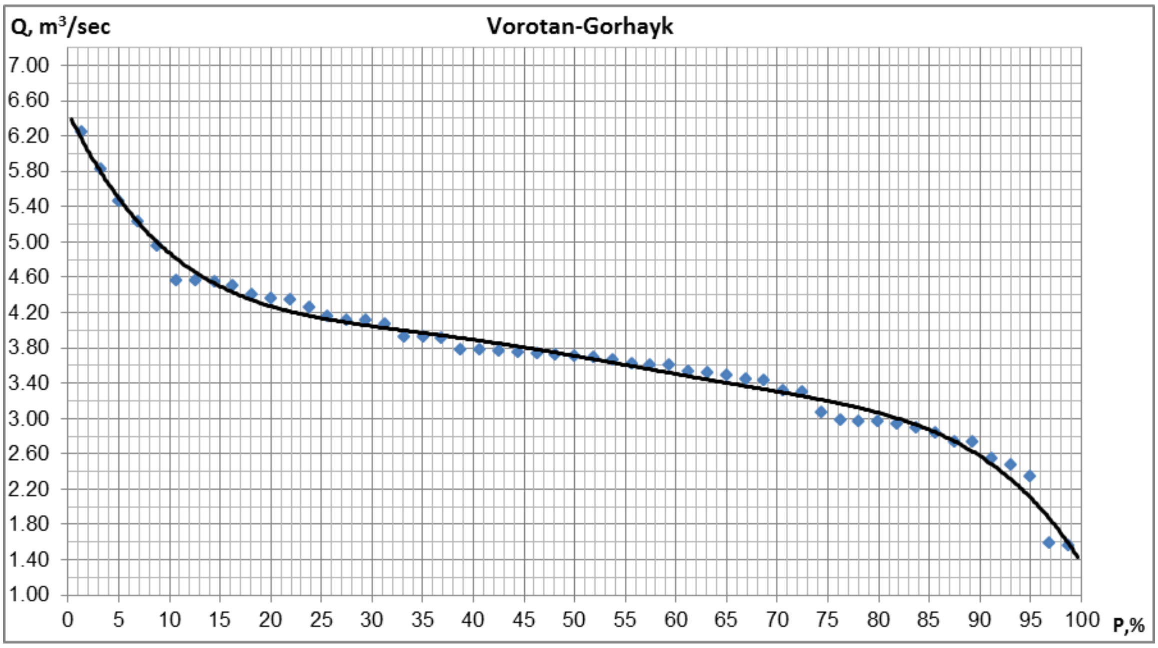

Q, m^3/sec
Gorisget-Goris
1.60
1.50
1.40
1.30
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
P, %


Q, m^3/sec
Tsghuk-Tsghuk
3.40
3.20
3.00
2.80
2.60
2.40
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
P,%


Q, m³/sec
Vorotan-Tatev
36.0
34.0
32.0
30.0
28.0
26.0
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
P, %


Q, m³/sec
Vorotan-Vorotan
29.0
27.0
25.0
23.0
21.0
19.0
17.0
15.0
13.0
11.0
9.0
7.0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
P,%


Q, m³/sec
Vorotan-Angeghakot
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
P,%



A value of occurrence of river discharge demonstrates in how many years (N) the river flow may occur for a given type of water year (P). The values of the river discharge are taken form the curve, while a value of occurrence is calculated using the following formula.

a) N=100/P, if P ≤50%,
b) N=100/(100-P), if P>50%.

For example, if P=75%, then N=100 / (100-75) =4. It means that the river discharge for year with 75% water availability may occur once in 4 years.

Correlation of the type of year, water availability and occurrence is presented below:

Water Availability, %	Type of year	Occurrence in N years
0.01	Catastrophic water abundance	10000
0.1	Catastrophic water abundance	1000
1	The most water abundance	100
3	Water abundance	33
5	Water abundance	20
10	Medium abundancy	10
25	Medium abundancy	4
50	Medium	2
75	Medium abundancy	4
90	Medium abundancy	10
95	Water shortage	20
97	Water shortage	33
99	The most water shortage	100
99.9	Catastrophic water shortage	1000
99.99	Catastrophic water shortage	10000

Annex B. Assessment of Water Quality in Rivers of the Southern BMA

B1. Classes of water quality in rivers of the Southern BMA, hydrochemical parameters that define the water quallty class and main drivers

River	*Monitoring post*	*Water quality class*	*Parameters that define water quality class*	*Main drivers*
Vorotan	0.5 km upstream the Gorhayk community	(II) Good	All parameters	
	1 km upstream the Sisian town	(IV) Poor	Phosphate ion	Diffuse sources of communal wastewaters, Return flows from agriculture
	2 km downstream the Sisian town	(IV) Poor	Phosphate ion	Communal wastewaters from the communities in upper reaches of the Vorotan River and Sisian town
	0.5 km downstream the Tatev HPP	(III) Moderate	Phosphate ion	Diffuse sources of communal wastewaters, Return flows from agriculture
Sisian	0.5 km upstream the Arevis community	(II) Good	All parameters	
	At the Tolors Reservoir	(II) Good	All parameters	
Gorisget	3 km upstream the Goris town	(IV) Poor	Phosphate ion	Diffuse sources of communal wastewaters, Return flows from agriculture
	1.5 կմ downstream the Goris town	(V) Bad	Ammonium and phosphate ions	Communal wastewaters from the communities in upper reaches of the Gorisget River and Goris town
Kishkisht	Upstream the Dastakert mine	*(II) Good	All parameters	
	At the Dastakert mine	*(V) Bad	Molybdenum	Surface runoff from non-operational Dastakert Copper-Molybdenum mine and tailing dam
Ayriget	Downstream the Souflu community, 100 m upstream the Kishkosht River confluence	*(II) Good	All parameters	
	100 m upstream the Kishkosht River confluence	*(V) Bad	Molybdenum	Surface runoff from non-operational Dastakert Copper-Molybdenum mine and tailing dam
Voghji	1.7 km upstream the Kajaran town	(II) Good	All parameters	
Voghji	1.8 km downstream the Kajaran town	(V) Bad	Ammonium and phosphate ions	Communal wastewater of the Kajaran town
	0.8 km upstream the Kapan town	(III) Moderate	Vanadium, iron, manganese, cobalt, molybdenum, antimony metals	Wastewaters of the Kajaran Combine, surface runoff from the territory of the open mine
	At the Kapan airport	(V) Bad	Manganese, cobalt, copper metals	Polluted waters of the Artsvanik, Norashenik and Kavart tributaries
	6.8 km downstream the Kapan town	(V) Bad	Manganese, cobalt, molybdenum metals	
Artsvanik	Downstream the tailing dam	(III) Moderate	Sodium, vanadium, iron, cobalt	Natural condition
	At the river mouth	(V) Bad	Mineralization elements (Na, K, SO_4^{2-}) and heavy metals (Mn, Mo, Sb)	Waters of the Artsvanik tailing pond
Geghi	0.5 km upstream the Ajabaj community	(II) Good	All parameters	
	At the Ajabaj community	(V) Bad	Manganese	Waters from the Ler-Ex LLC tailing dam
	At the river mouth	(II) Good	All parameters	

River	Monitoring post	Water quality class	Parameters that define water quality class	Main drivers
Vacha-gan	In the Kapan town	**(II) Good	All parameters	
Tsav	At the Tsav community	**(II) Good	All parameters	
Meghriget	Headwaters	(II) Good	All parameters	
	0.5 km downstream the Tghkut community	***(V) Bad	Chromium, iron, manganese, cobalt, nickel	Flows from the waste dumps and settling ponds of the Lichkvaz-Tey mine
	0.5 km upstream the Meghri town	(II) Good	All parameters	
	At the river mouth	(II) Good	All parameters	
Boghakar	Middle reaches of the river, Upstream the Lichkvaz-Tey mine	***(II) Good	All parameters	
	At the river mouth	***(II) Good	All parameters	
Karchevan	At the river mouth	(V) Bad	Mineralization elements, heavy metals, organic substances	Wastewater from the Agarak Combine

* according to data for 2011-2012 from the EIA Report prepared by the Molybdenum World LLC

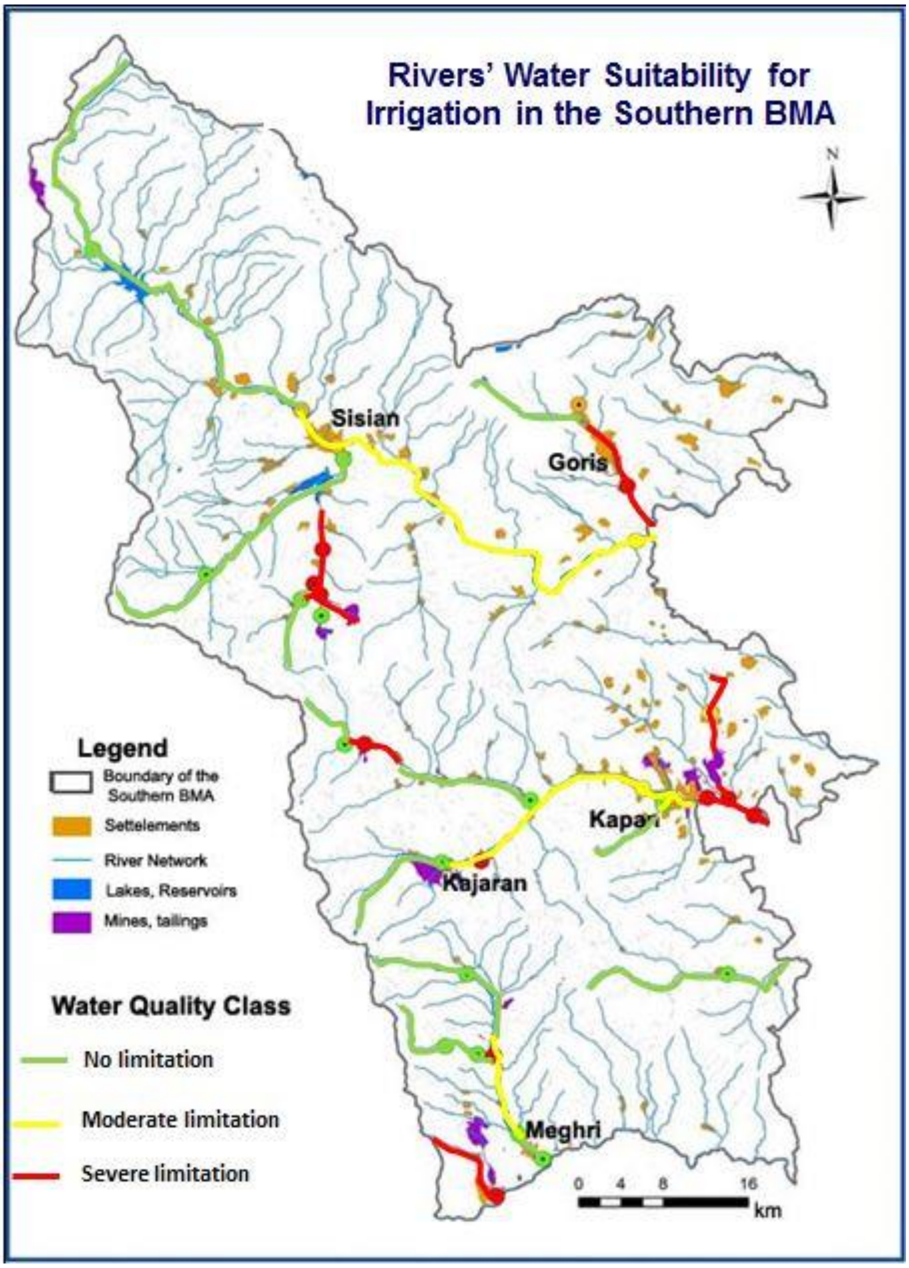
** according to hydrochmical monitoring data from 2006

*** according to data for 2011-2012 from the EIA Report prepared by Sagamar CJSC

B2. Assessment of suitability of water resources in the Southern BMA for use for irrigation, fish breeding and drinking based on quality of water resources in 2013

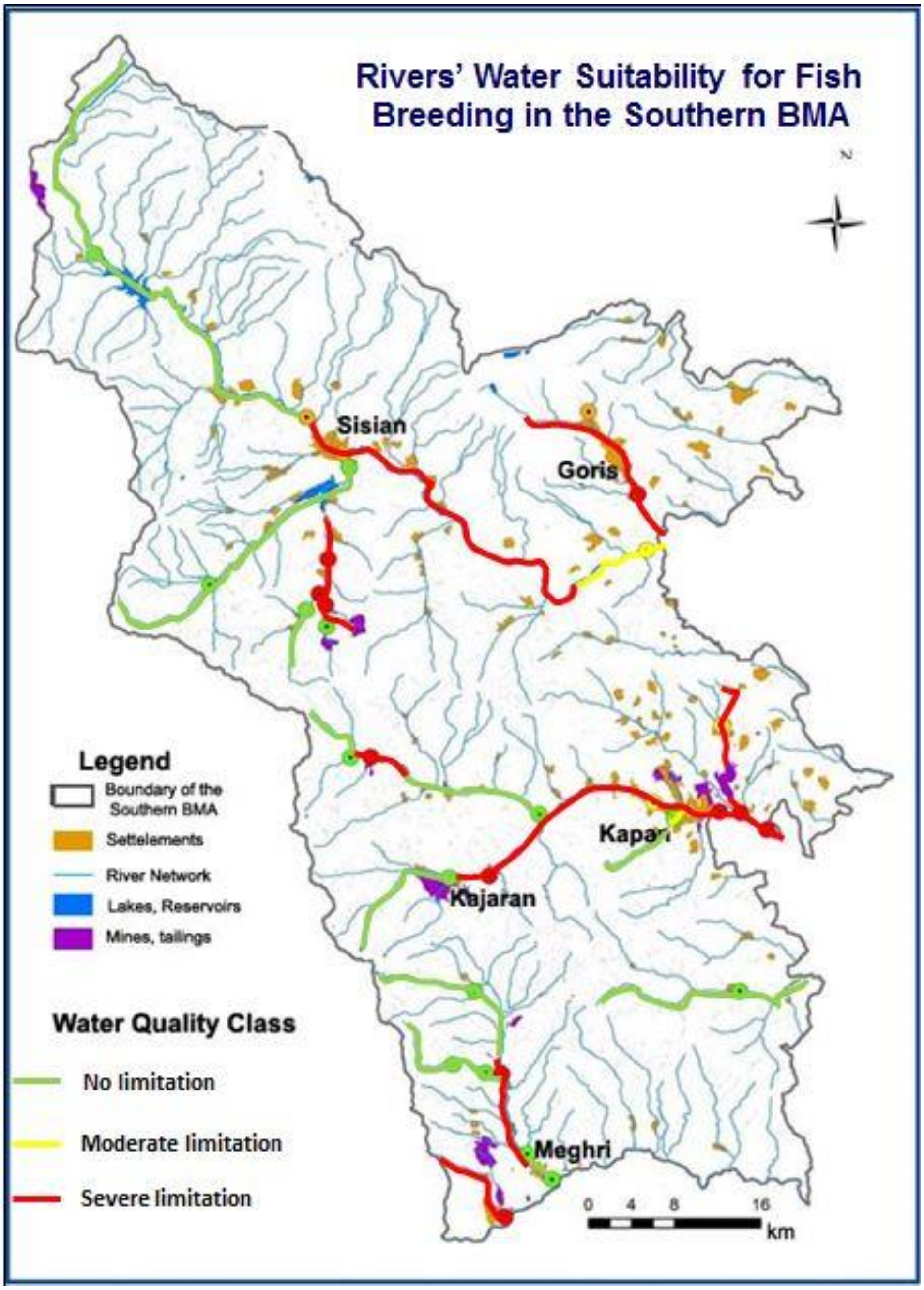
River	River Stretch	Limitation for water use for:		
		Irrigation	Fish breeding	Drinking-Household
Vorotan	Upper reaches, before the Spandaryan Reservoir	Without limitation	Allowed both for salmon and carp species	Can be used for drinking-household purposes based on the quality, after disinfection/pre-treatment
	From the Spandaryan Reservoir to the Sisian town			Not allowed
	From Sisian town to the Tatev HPP	Moderate limitation	Not allowed	
	From Tatev HPP to the RA border		Allowed for carp species only	
Sisian	Upper reaches, before the Arevis settlement	Without limitation	Allowed both for salmon and carp species	Can be used for drinking-household purposes based on the quality, after disinfection/pre-treatment
	From Arevis settlement to the river mouth			Not allowed
Gorisget	Upper reaches, before the Goris town	Without limitation	Not allowed	Not allowed
	From Goris town to the RA border	Not allowed		
Voghji	Upper reaches, before the Kajaran town	Without limitation	Allowed both for salmon and carp species	Not allowed
	From Kajaran town to the Kapan Airport	Moderate limitation	Not allowed	
	From Kapan airport to the RA border	Not allowed		
Artsvanik	Whole river	Not allowed	Not allowed	Not allowed
Geghi	Upper reaches, before the Ajabaj settlement	Without limitation	Allowed both for salmon and carp species	Can be used for drinking-household purposes based on the quality, after disinfection/pre-treatment
	From Ajabaj to the Nor Astghaberd settlement	Not allowed	Not allowed	Not allowed
	From Nor Astghaberd settlement to the river mouth	Without limitation	Allowed both for salmon and carp species	
Vachagan	Upper reaches, before the Kapan town	Without limitation	Allowed both for salmon and carp species	Not allowed
	Within the Kapan town and before the river mouth	Moderate limitation	Allowed for carp species only	
Tsav	Upper reaches, before the first arable land plot	Without limitation	Allowed both for salmon and carp species	Can be used for drinking-household purposes based on the quality, after disinfection/pre-treatment
	Whole river			Not allowed
Meghriget	Upper reaches, before the Lichk settlement	Without limitation	Allowed both for salmon and carp species	Can be used for drinking-household purposes based on the quality, after disinfection/pre-treatment

<table>
<tr><th rowspan="2">River</th><th rowspan="2">River Stretch</th><th colspan="3">Limitation for water use for:</th></tr>
<tr><th>Irrigation</th><th>Fish breeding</th><th>Drinking-Household</th></tr>
<tr><td rowspan="3"></td><td>From Lick to the Tkhkut settlement</td><td></td><td></td><td rowspan="3">Not allowed</td></tr>
<tr><td>From Tkhkut settlement to the Meghri town</td><td>Moderate limitation</td><td>Not allowed</td></tr>
<tr><td>Downstream the Meghri town, up to the river mouth</td><td>Moderate limitation</td><td>Allowed for carp species only</td></tr>
<tr><td>Boghakar</td><td>Whole river</td><td>Without limitation</td><td>Allowed both for salmon and carp species</td><td>Not allowed</td></tr>
<tr><td>Karchevan</td><td>Whole river</td><td>Not allowed</td><td>Not allowed</td><td>Not allowed</td></tr>
</table>



Assessment of suitability of water resources in the Southern BMA for irrigation, as of 2013

Source: USAID Clean Energy and Water Program, 2014 (coordinate system WGS. UTM Zone 38N)



Assessment of suitability of water resources in the Southern BMA for fish breeding, as of 2013

Source: USAID Clean Energy and Water Program, 2014 (coordinate system WGS. UTM Zone 38N)

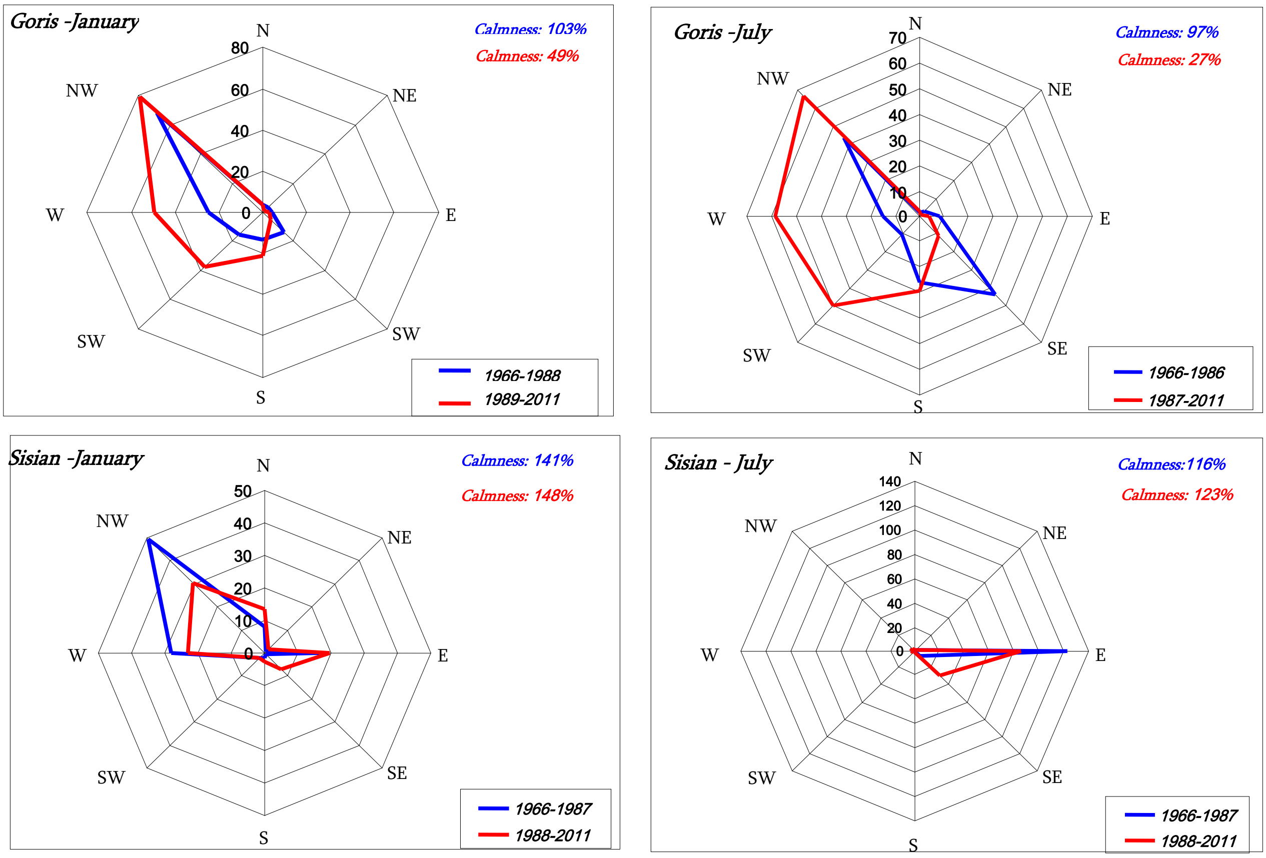
Appendix C. Assessment of Climate Change in the Southern BMA

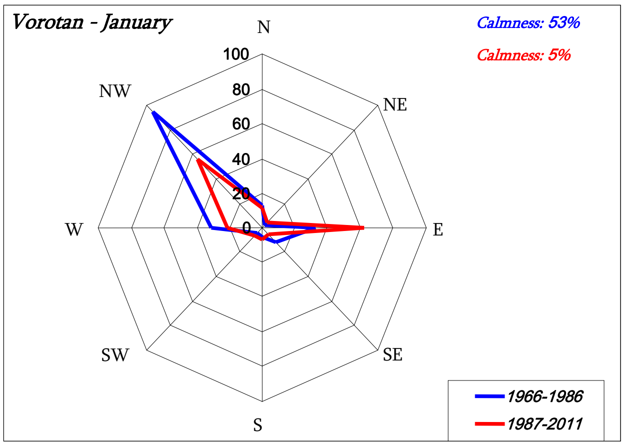
C1. Changes in Wind Direction and Speed in the Southern BMA

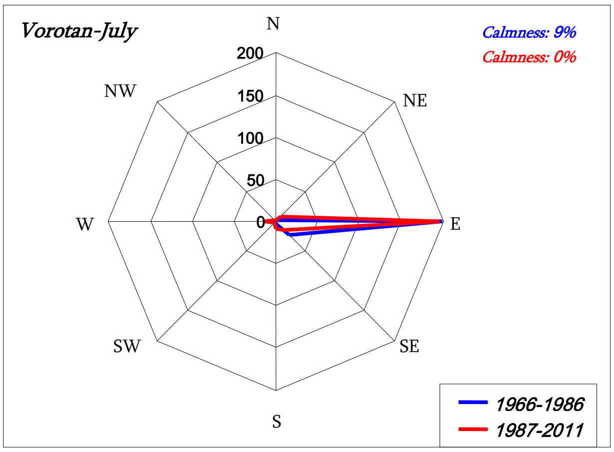
Changes in wind direction due to global climate change impact redistribution of precipitation in the basin. The prevailing wind directions and frequency of calm days in the Southern BMA were assessed for the months of January and July in the period of 1989-2011 against the average values for 1966-1988. According to the results of the assessment, no significant changes in wind directions were observed at almost all the stations of the Vorotan River Basin, only in Goris station a slight increase in frequency of western and south-western winds in the summer months is observed for the last 25 years. An increase in the direction of south-eastern winds is also observed in the Voghji River Basin, particularly in Kapan, reaching from 20% to 81% both in January and July. Another deviation of wind direction is observed in the Meghriget River Basin, where the prevailing south-eastern winds of January have become of eastern direction – having increased from 20% to 36%, and the prevailing eastern winds of July are maintained by about 50%, whereas the south-eastern direction of winds has decreased by about 20%.

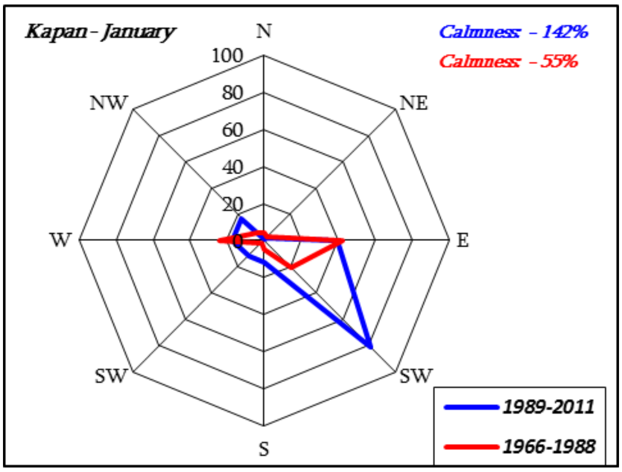
As to the changes in the frequency of calm days in the Southern BMA, it has decreased by 50-70% in the Vorotan River Basin with the highest drop recorded in the Vorotan Mountain Pass, by 61-68% in the Voghji River Basin, especially in Kapan, whereas in the Meghriget River Basin it has increased by 27% and 37% in January and July, respectively.

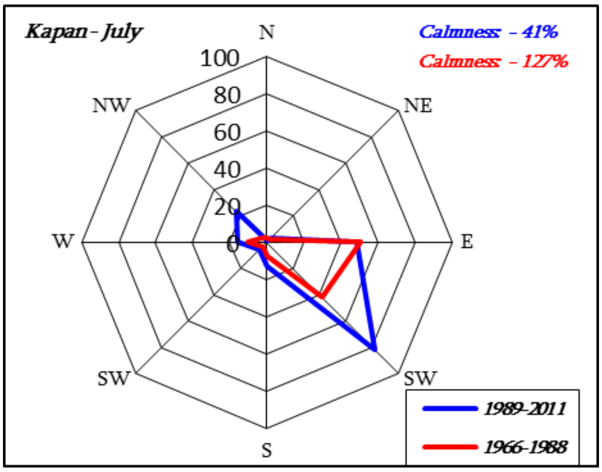
Changes in the Trends of Wind Direction and Frequency of Calm Days in January and July in the Southern BMA during 1989-2011 against the average values for 1966-1988.

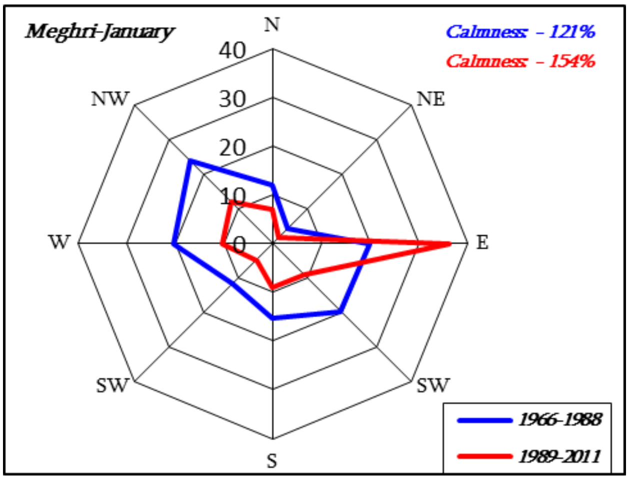


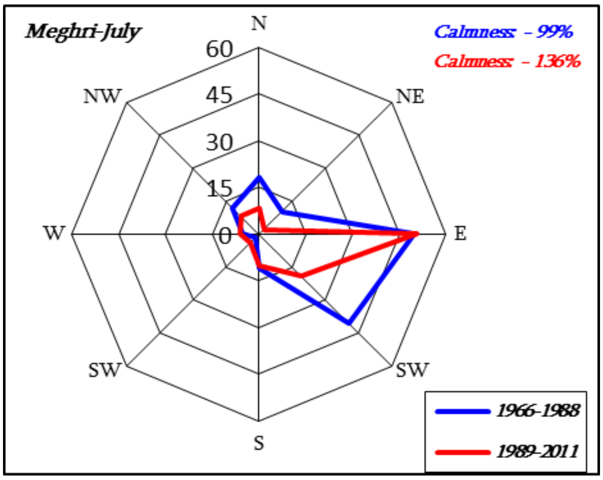






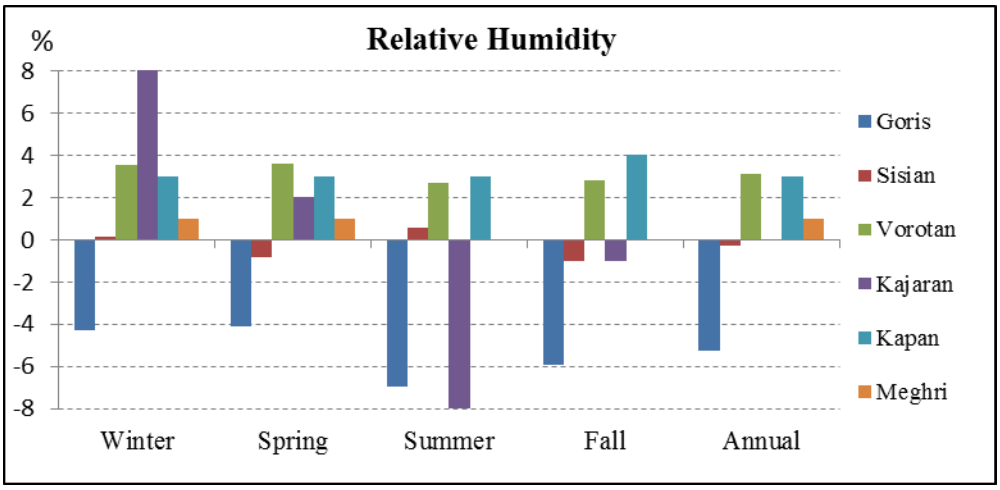






Wind speed in the Southern BMA is significantly lower from the one in the territory of the Republic and it considerably fluctuates spatially. The annual wind speed in the Voghji and Meghriget River Basins is about 1.2m/sec., whereas in the Vorotan River Basin, especially in the Vorotan Mountain Pass, the magnitude of winds becomes higher throughout the year, by reaching up to 5.5-6.8m/sec. in the summer months. According to the analysis of seasonal and annual values of wind speed in the Southern BMA, in the period of 1986-2011the wind speed has decreased by 0.4-1m/sec. in Sisian, by 0.3-0.6 m/sec. in Kajaran, by 0.6-0.9 in Meghri (with maximum decreased observed in the summer months), whereas it has increased by 0.5-0.6 m/sec. in Kapan. An increase in seasonal and annual average wind speed is observed also in Goris and Vorotan Mountain Pass during all seasons.

C.2 Deviations of Seasonal and Annual Mean Values of Relative Humidity in the Southern BMA in 1988-2011 against the Baseline Average Values for 1966-1987.



C3. Analysis of Climate Extreme Indices

The analysis of climate extremes indices was performed using the RClimDex (1.0) software package developed by the Center for Climate Studies of the Canadian Meteorological Service. There are about 40 indices, out of which the 14 indices listed in the Table below have been selected and analyzed for the Southern BMA.

Abbreviations, Terminological Expressions and Definitions of the Climate Extreme Indices

	Abbreviation	Term	Definition	Unit
1.	CDD	Consecutive dry days	Maximum duration of consecutive dry days, when the daily precipitation quantity is smaller than 1mm, RR_{ij}<1mm	day
2.	RX1day	Max 1-day precipitation amount	Monthly maximum 1-day precipitation	mm
3.	Rx5day	Max 5-day precipitation amount	Monthly maximum consecutive 5-day precipitation	mm
4.	R10	Number of heavy precipitation days	Annual count of days, when daily precipitation is 10mm and more (PRCP>=10mm)	day
5.	R20	Number of very heavy precipitation days	Annual count of days, when daily precipitation is 20mm and more (PRCP>=20mm)	day
6.	GSL	Growing season length	Annual (1^{st} Jan to 31^{st} Dec in NH, 1^{st} July to 30^{th} June in SH) count between first span of at least 6 days with TG>5ºC and first span after July 1 (January 1 in SH) of 6 days with TG<5ºC	day
7.	FD0	Frost days	Annual count of days, when daily minimum temperature is below 0ºC, TN(daily minimum)<0ºC	day
8.	SU25	Summer days	Annual count of days, when daily maximum temperature is above 25ºC, TX(daily maximum)>25ºC	day
9.	ID0	Ice days	Annual count of days, when daily maximum temperature is below 0ºC, TX(daily maximum)<0ºC	day
10.	TN10p	Cool nights	Percentage of days when daily minimum temperature is less than 10^{th} percentile, TN<10th percentile	day
11.	TN90p	Warm nights	Percentage of days, when daily minimum temperature is more than 90^{th} percentile, TN>90th percentile	day

12.	TR20	Tropical nights	Annual count of days, when daily minimum temperature is above 20ºC, TN(daily minimum)>20ºC	day
13.	TX10p	Cool days	Percentage of days, when daily maximum temperature is less than 10th percentile, TX<10th percentile	day
14.	TX90p	Warm days	Percentage of days, when daily maximum temperature is more than 90th percentile, TN>90th percentile	day

The maximum and minimum daily temperature and precipitation data for the period of 1961-2011 have been used for analyzing the climate extreme indices in the Southern BMA. Due to data gaps and/or non-reliability of systemaic observation daily data time series, it has not been possible to carry out the analysis for all the indices for every individual meteorological station. The analysis was implemented by comparing deviations in the average values of indices in the period of 1986-2011 against the average for 1961-1985. The results are summarized in the Table below.

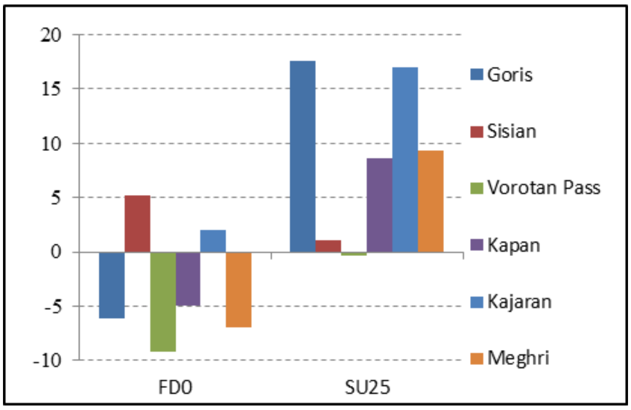
Deviations of Climate Extreme Indices against the Baseline Average values

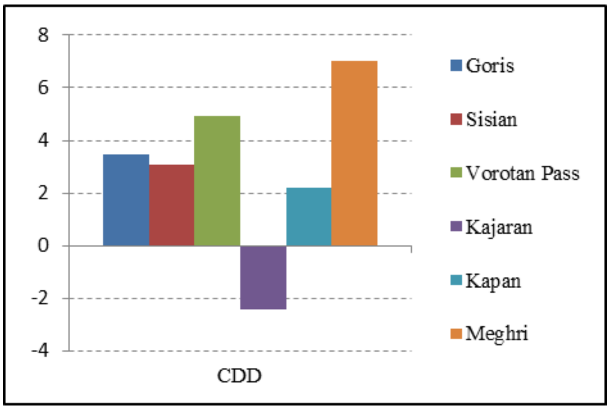
Index	Description of Deviations
SU25	Increased by 17 days in Goris, 17 days in Kajaran, 8 days in Kapan, 9 days in Meghri, no significant changes observed in Sisian and Vorotan Mountain Pass.
FD0	Decreased by 6-9 days in Goris and Vorotan Mountain Pass, 5 days in Kapan, 7 days in Meghri, whereas it increased by 2 days in Kajaran and by 3-5 days in Sisian.
TN90p and TX90p	Warm nights and warm days have become more frequent in Goris at all seasons. Intra-seasonal fluctuations are observed in Sisian and Vorotan Mountain Pass. In Kapan prolonged warm days are observed throughout the year, the number of warm nights has increased by 2 days in summer. An increase in these two indices is observed in Meghri almost during all seasons, particularly, the number of warm days has increased by 8 days throughout the year, and the number of warm nights has increased by 8 days in summer and fall months.
TN10p and TX10p	The number of cool nights and days has significantly decreased in all stations of the Southern BMA. Particularly, the highest deviation is observed in summer months – by 4-6 days in the Vorotan and Voghji River Basins, and by 5-7 days in the Meghriget River Basin.
GSL	The duration of growing season has increased in all three river basins of the Southern BMA – an average by 3-4 days in the Vorotan River Basin, by 2.5 days in the Voghji River Basin (in Kapan), and by 6 days in the Meghriget River Basin.

Changes in indices that characterize precipitation, generally, did not follow any pattern. They have irregular spatial distribution, and the intra-annual fluctuations are not very significant.

R10	The number of days with heavy precipitation has decreased by 2 and 4.5 days in Goris and Vorotan Mountain Pass, respectively, 2 days in Kapan and 12 days in Kajaran. An increase in the mentioned index is observed by 1.2 days in Sisian, and has almost not changed in the Meghriget River Basin.
R20	No major change in the number of days with very heavy precipitation was observed in the Vorotan and Meghrivet River Basins; it decreased only in Kapan by 2 days and in Kajaran – by 4 days.
RX1day and Rx5day	The values of 1-day and 5-day maximum precipitation decreased throughout the year by 1-3mm in Goris, 2-10mm in Vorotan Mountain Pass, and 6-7mm in Meghri. The highest deviation was obsderved in Kajaran and Kapan, where the values decreased by up to 14mm. In Sisian, however, the intensity of 1-day and 5-day maximum precipitation increased in fall and spring, slightly decreased in summer, and almost did not change in winter.
CDD	The maximum duration of consecutive dry days has increased in almost all locations of the Southern BMA, in particular, by 3-5 days in the Vorotan River Basin, by 2.2 days in Kapan and by 7 days in Meghri. It has only decreased in Kajaran – by 2.4 days.

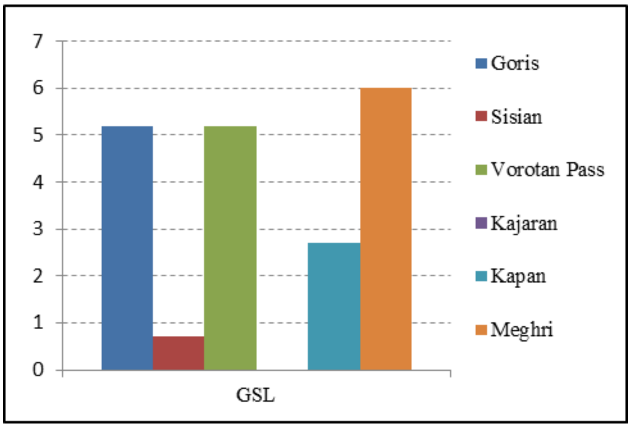
Deviations of Seasonal and Annual Values of the Climate Extreme Indices from the Baseline Average Values



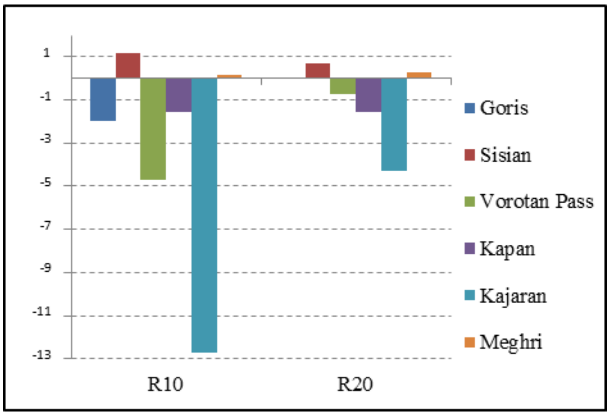


Deviations in annual average number of “summer Days” (SU25) and “Frost Days” (FD0) in 1986-2011 against the average for 1961-1985.

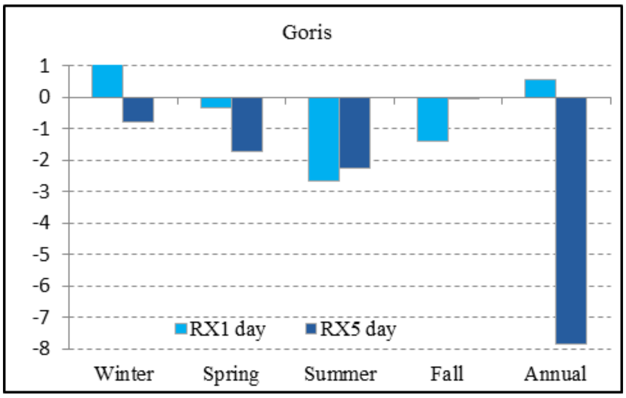
Deviations in annual number of “Consecutive Dry Days” (CDD) in 1986-2011 against the average for 1961-1985.

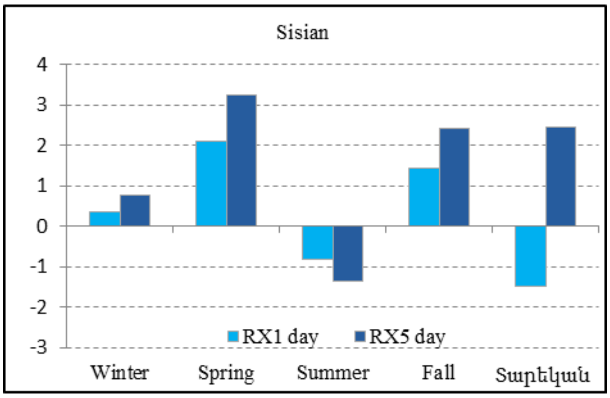


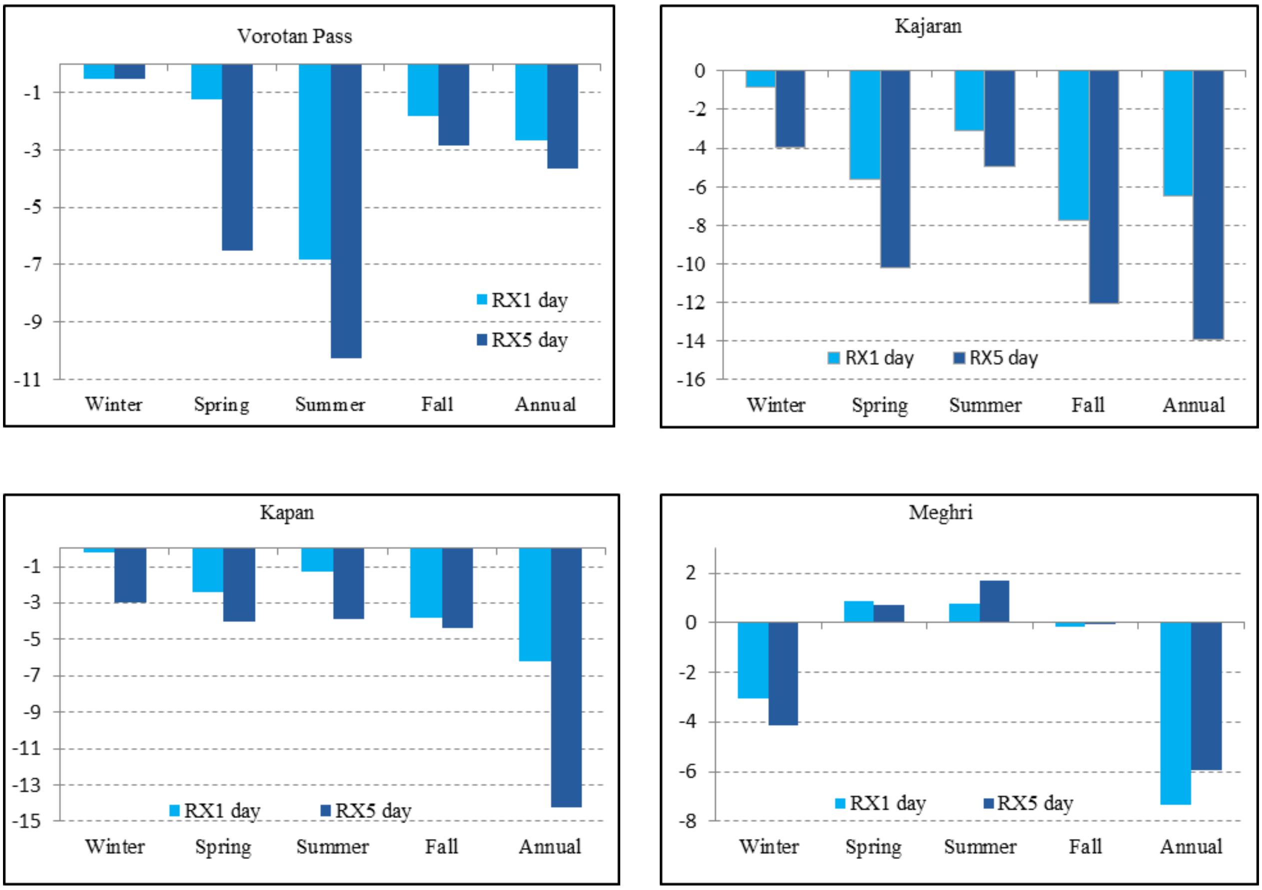
Deviations in annual average number of “Growing Season Length” days (GSL) in 1986-2011 against the average for 1961-1985.



Deviations in annual average number of days with heavy (R10) and very heavy precipitation (R20) in 1986-2011 against the average for 1961-1985.







*Deviations in annual average number of days with "*Max 1-day precipitation amount" (*RX1day*) and "Max 5-day precipitation amount" (*RX5day*) *in 1986-2011 against the average for 1961-1985.*

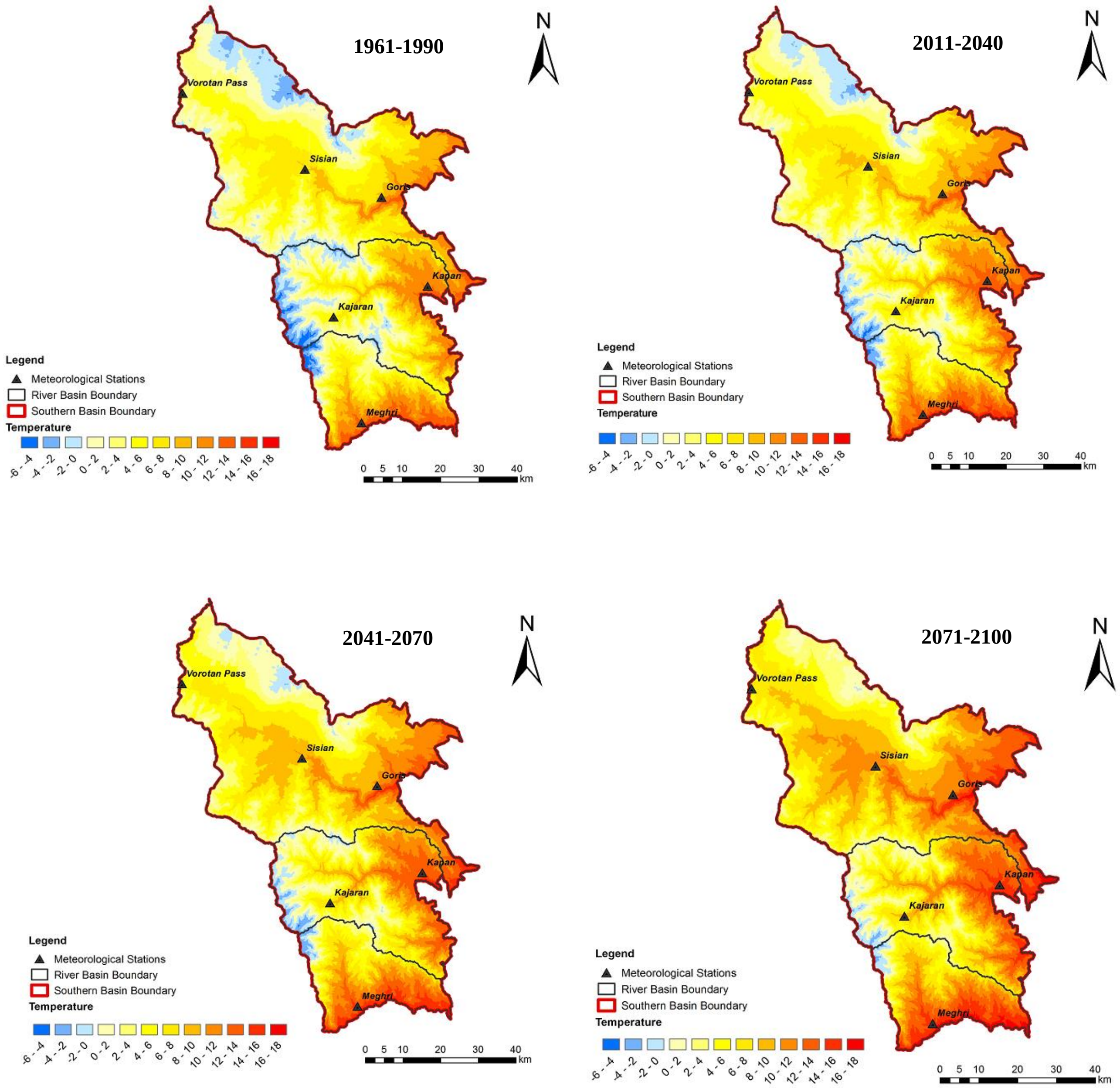
C4. Hazardous Hydrometeorological Phenomena in the Southern BMA

The frequency and intensity of hazardous hydrometeorological phenomena in the territory of the Republic of Armenia have evidently increased during the recent decades, which may contribute to the occurance of natural disasters inducing harms to population, environment and economy. The hazardous hydrometeorological phenomena analyzed for the Southern BMA include frost, hail and strong winds. According to the analyses, no specific dynamics of changes in these phenomena have been observed in the Basin area. For example, incidences of hailstorm have decreased in Goris, Kapan and Meghri by 2-6 cases against the average number. The number of frost days has increased in Voghji and Meghriget River Basins by 0.5 and 1.7 days, respectively, during 1971-2011. The number of days with strong winds over 15 m/sec. has decreased in all the three river basins, including by 1.7 cases in the Voghji River Basin and by 2 cases in the Meghriget River Basin.

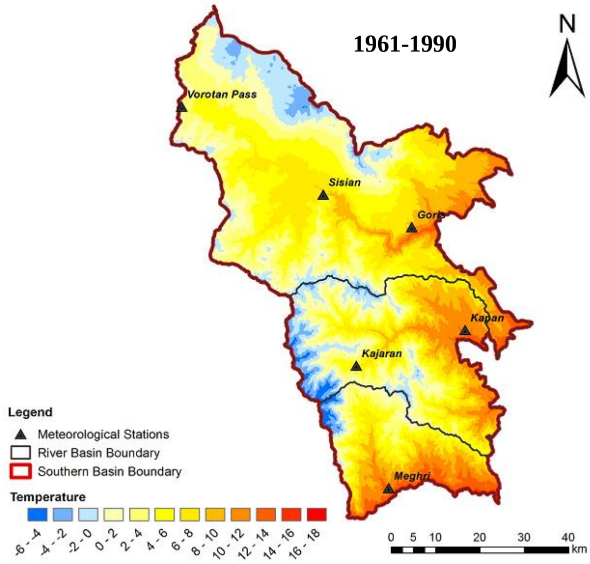
C5. Projected Annual Average Temperature (^{0}C) in the Southern BMA in 2011-2040, 2041-2070 and 2071-2100 in Comparison with the Baseline Average Values for 1961-1990.

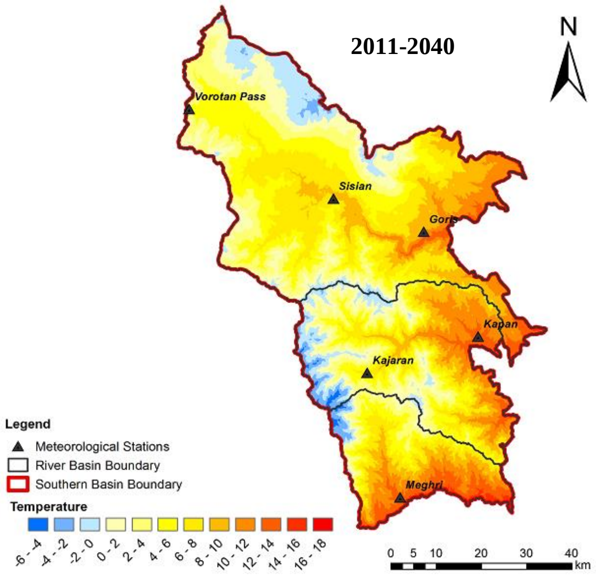
Projections of climate change for the Southern BMA were performed with PRECIS regional climate modeling system, which is based on the third generation regional climate model (HadRM3), developed by the UK Met Office Hedley Center. HadRM3 uses the output data of global climate models (GCMs), as well as actual observation data, and empiric-statistical methods to perform a dynamic downscaling, in order to acquire regional scale climate projections with a resolution of $0.22^{0} \times 0.22^{0}$ (25 x 25km).

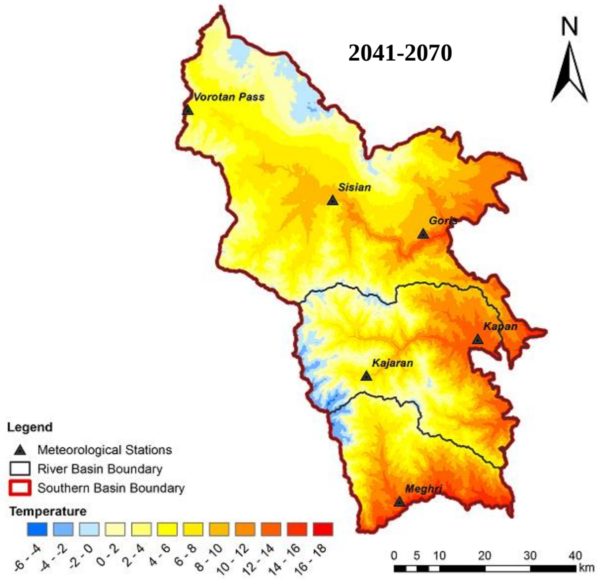
IPCC A2 Scenario

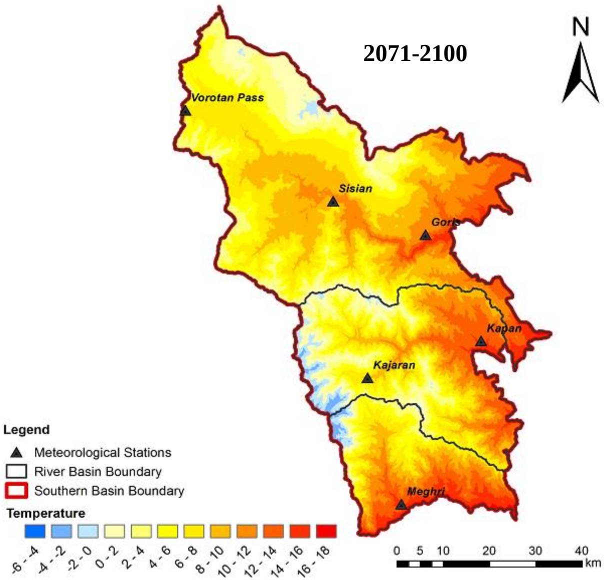


IPCC B1 Scenario



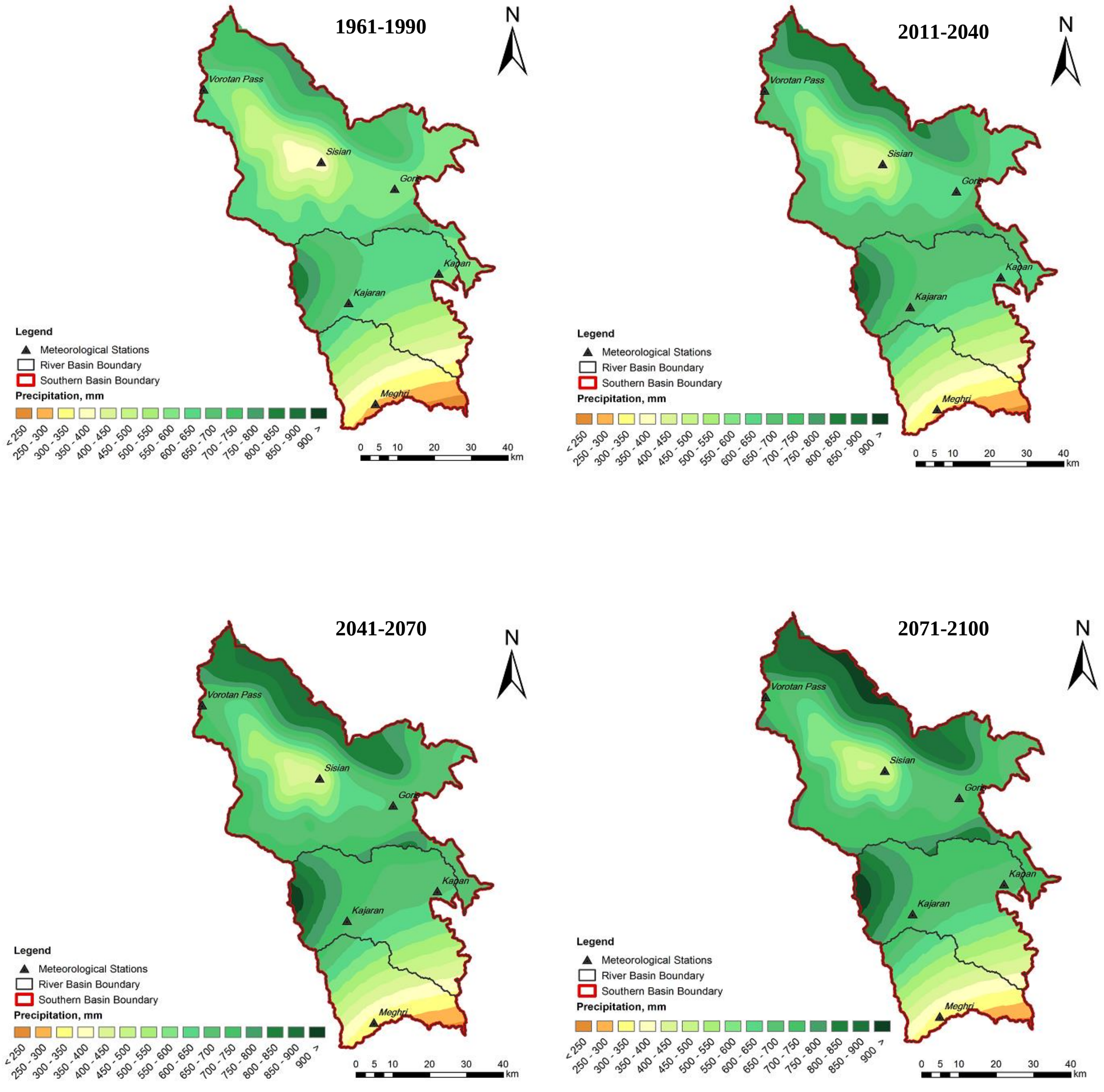




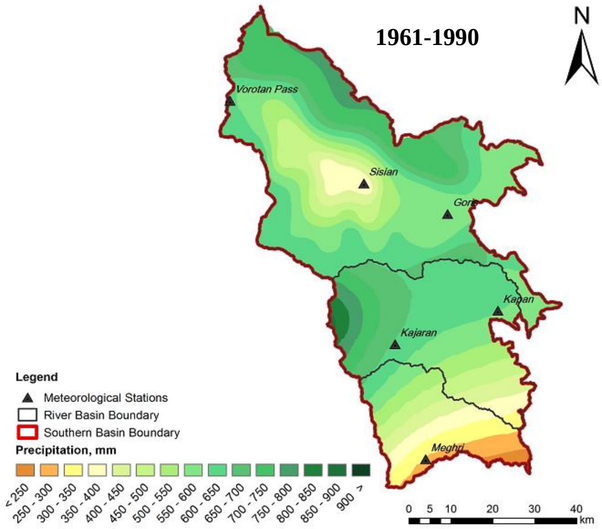


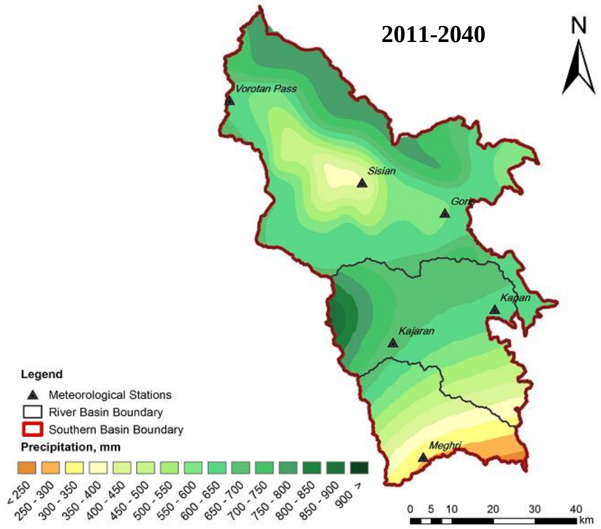
C6. Projected Annual Precipitation (mm) in the Southern BMA in 2011-2040, 2041-2070 and 2071-2100 in Comparison with the Baseline Average Values for 1961-1990.

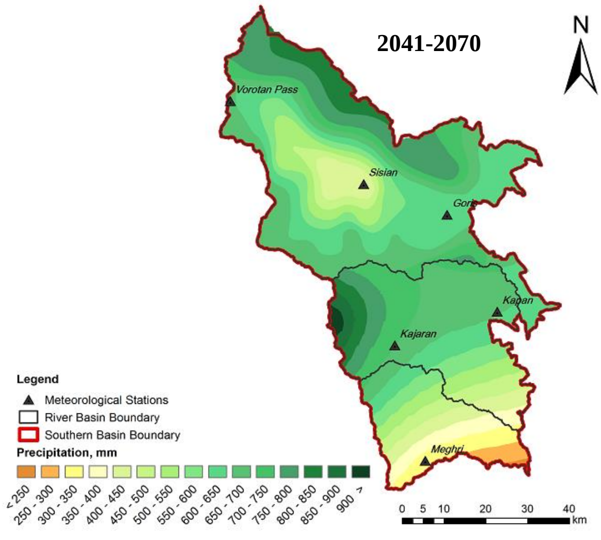
IPCC A2 Scenario

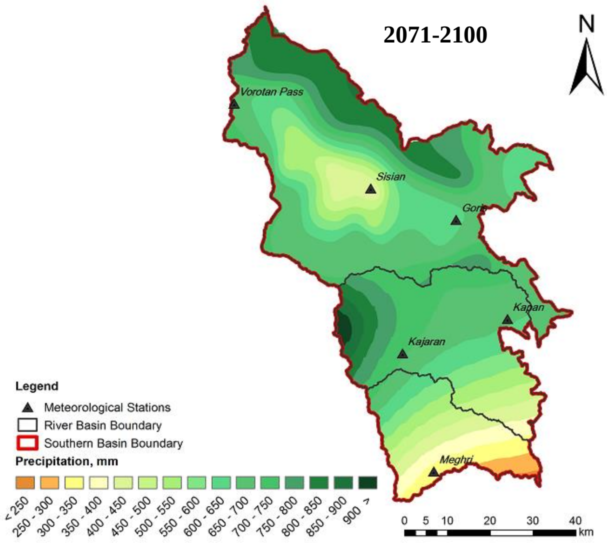


IPCC B1 Scenario



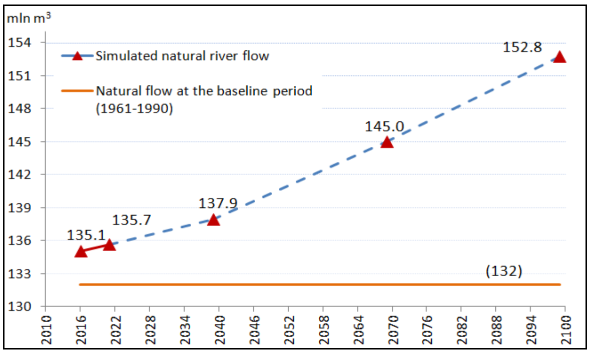




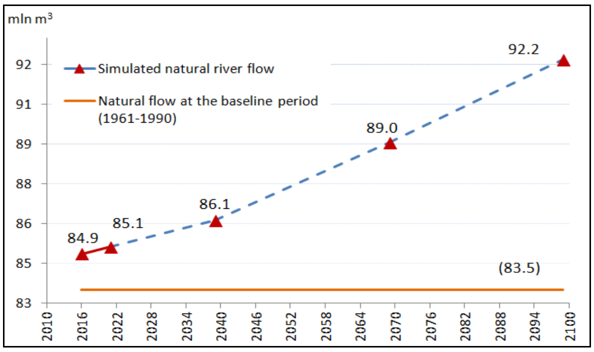


C7. Simulated Annual Natural River Flow in the Southern BMA for 2040, 2070 and 2100 under IPCC A2 Scenario

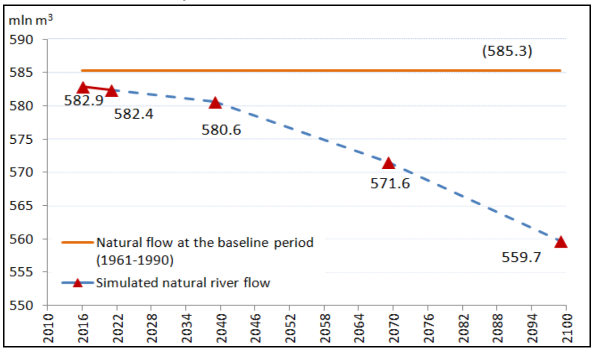
a/ Vorotan-Gorhayk



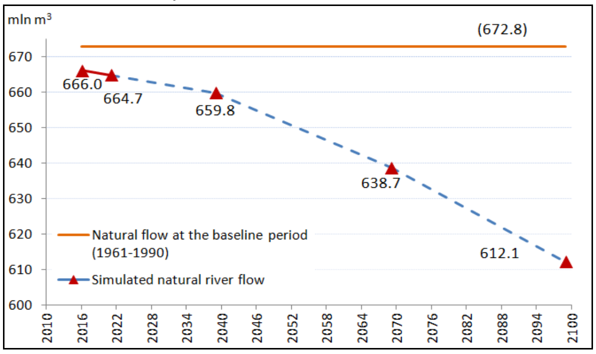
b/ Tsghuk-Tsghuk



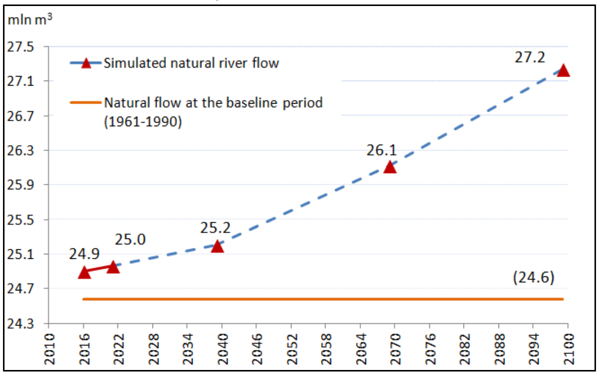
c/ Vorotan-Vorotan



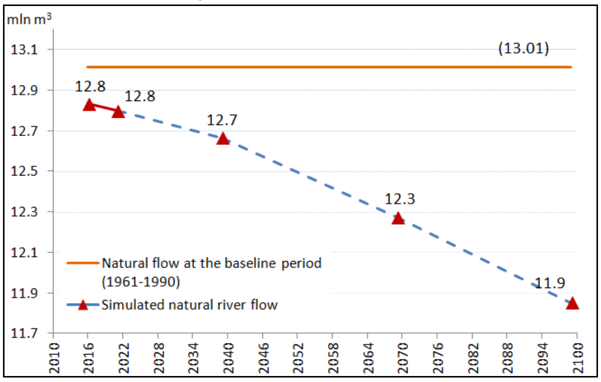
d/ Vorotan-Tatev HPP



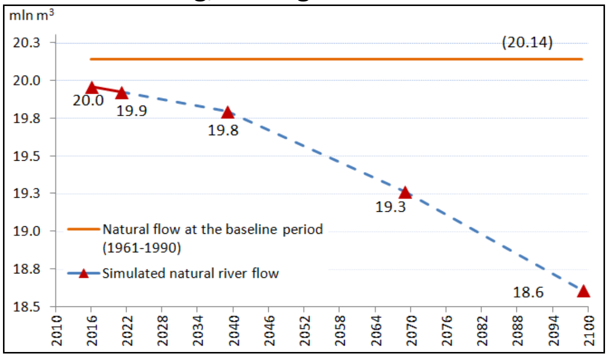
e/ Sisian-Arevis



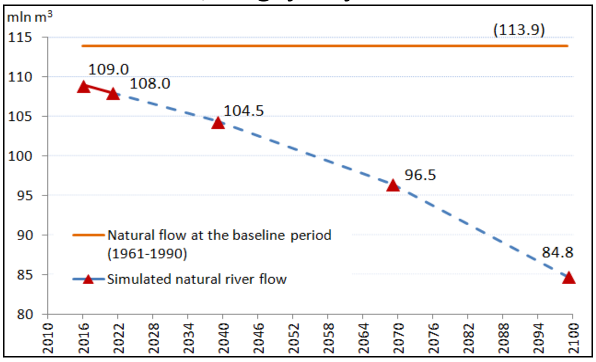
f/ Loradzor-Ltsen



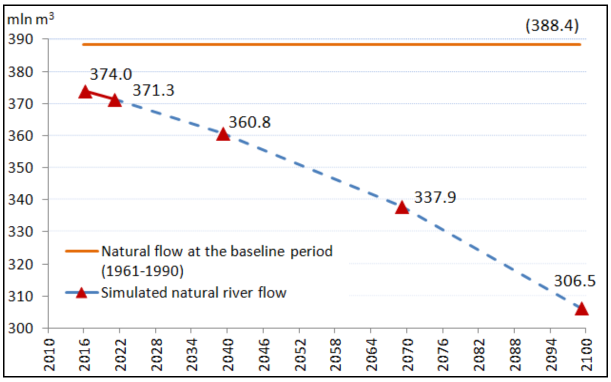
g/ Gorisget-Goris



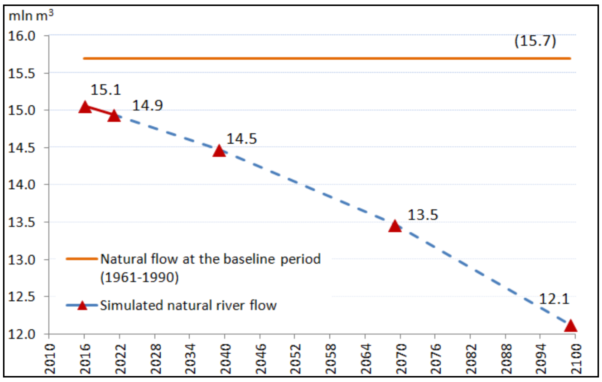
h/ Voghji-Kajaran



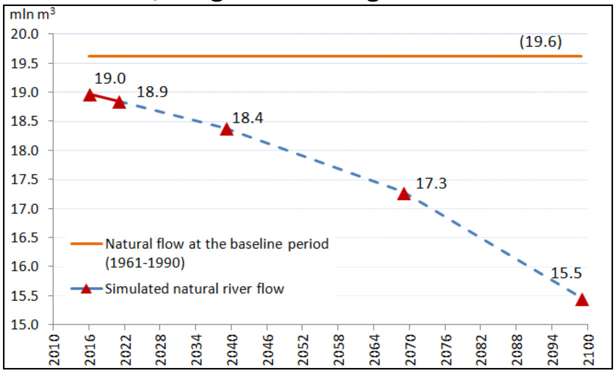
i/ Voghji-Kapan



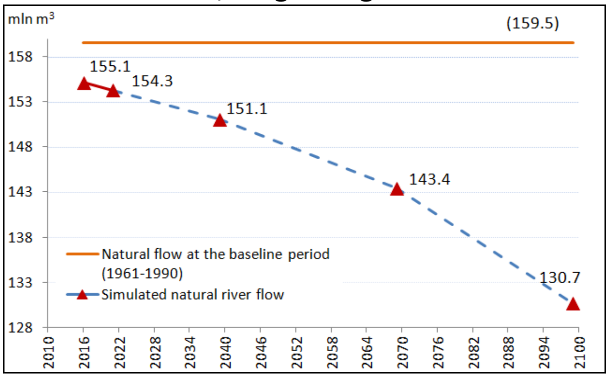
j/ Vachagan-Kapan



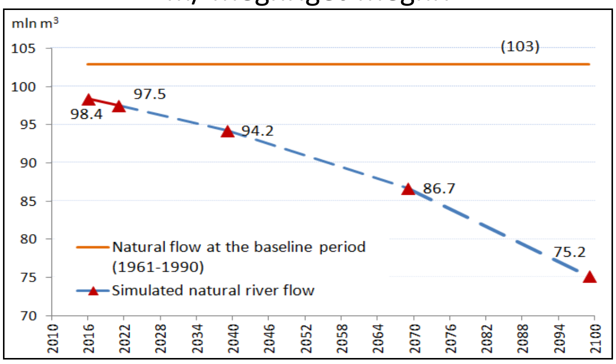
k/ Geghanush-Geghanush



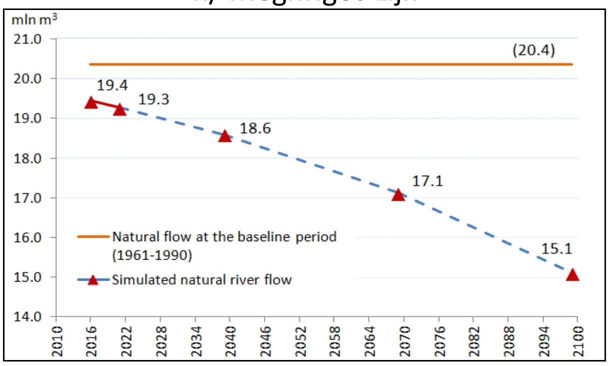
l/ Geghi-Geghi



m/ Meghriget-Meghri

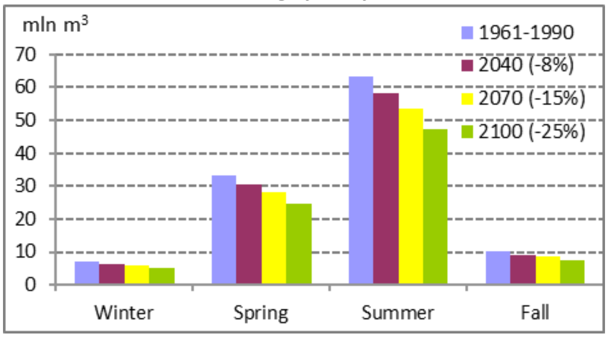


n/ Meghriget-Lijk

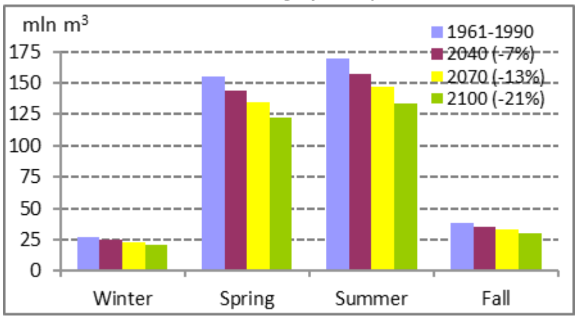


C8. Seasonal Values of Simulated Natural River Flow in the Southern BMA for 2040, 2070 and 2100, under IPCC A2 scenarios

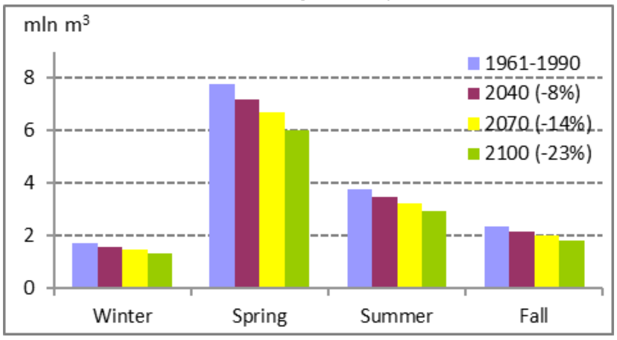
a/ Voghji-Kajaran



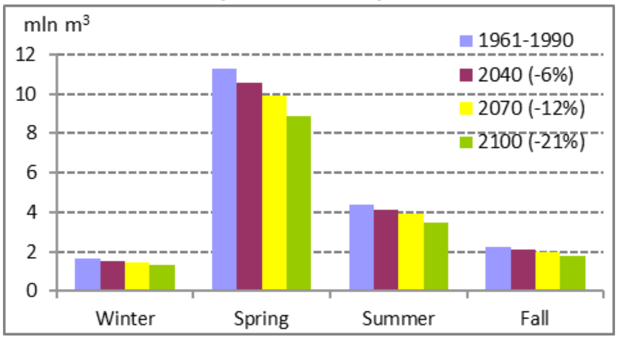
b/ Voghji-Kapan



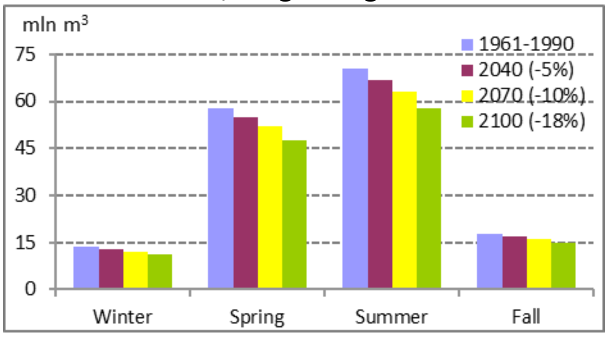
c/ Vachagan-Kapan



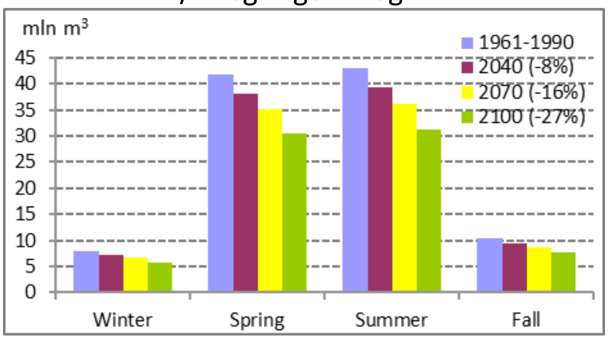
d/ Geghanush-Geghanush



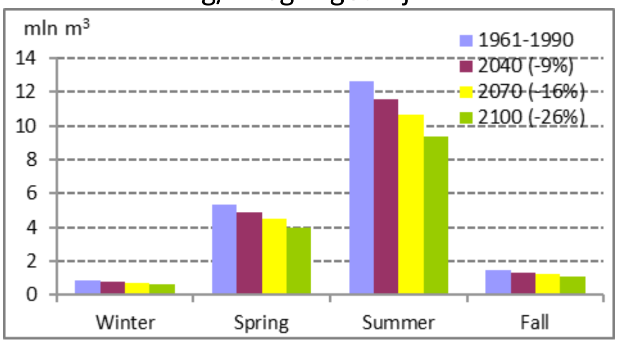
e/ Geghi-Geghi



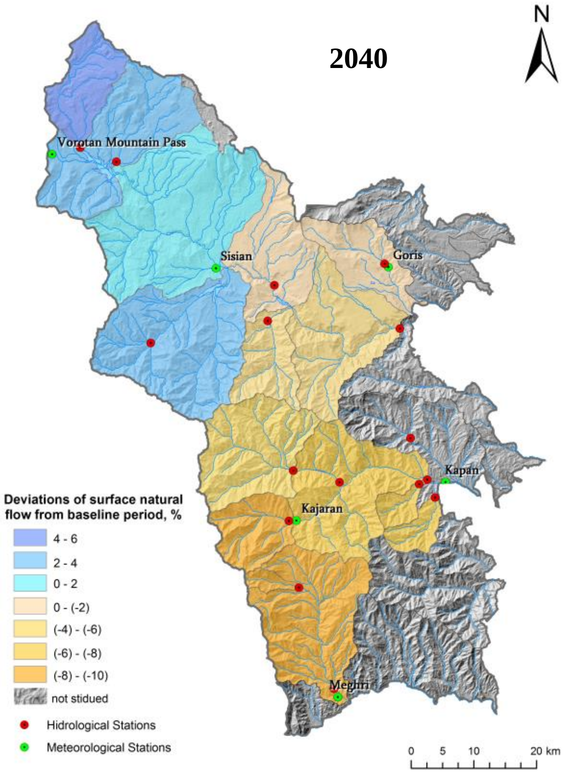
f/ Meghriget-Meghri

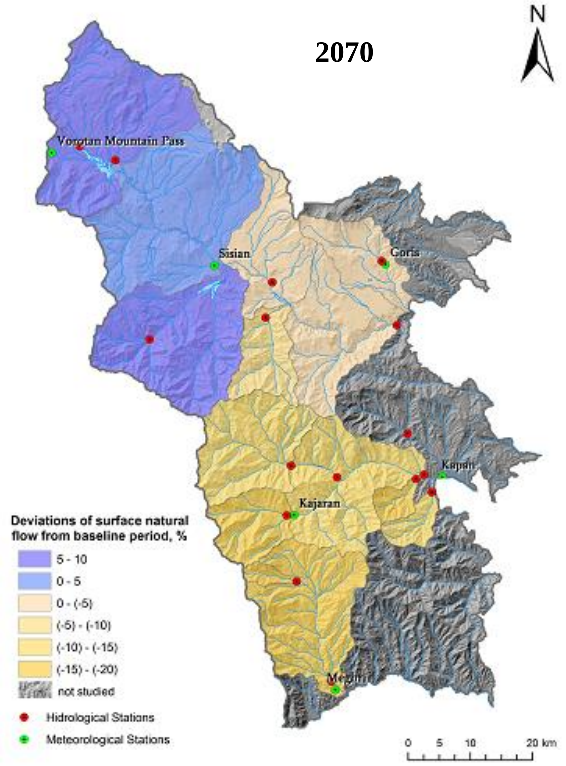


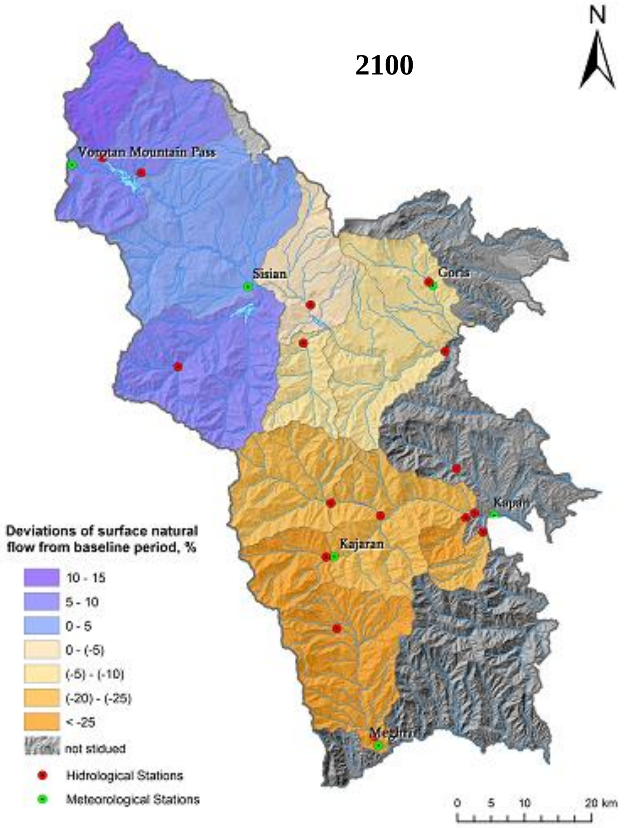
g/ Meghriget-Lijk



C9. Deviation of the Natural River Flow in the Southern BMA in 2040, 2070 and 2100, against the baseline average for 1961-1990, under IPCC A2 Scenario







Annex D. Surface Water Bodies Delineated in the Southern BMA

#	Type	Name/ Location	Length, m	Area, km^2
1	WB-01	The Vorotan River up to the Spandaryan Reservoir	72972	
2	WB-02	Small rivers discharging into the Spandaryan Reservoir	101925	
3	WB-03	TheTsghuk and Mokhraget Rivers, up to the Spandaryan Canal	54580	
4	WB-04	The Mokhraget River from the Spandaryan canal to Spandaryan Reservoir	4347	
5	WB-05	The Aragiljur River, up to confluence with the Vorotan River	50802	
6	WB-06	The Shagar River to confluence with the Vorotan River	19589	
7	WB-07	The Vorotan River, from the Spandaryan Reservoir to Angeghakot Reservoir	17356	
8	WB-08	The Vorotan River, from the Angeghakot Reservoir to confluence with the Shaqi River	4194	
9	WB-09	The Vorotan River, from confluence point with the Shaqi Riverin the Sisian town	4510	
10	WB-10	The Brnakot River with its tributaries	28588	
11	WB-11	The Sisian River, from its headwaters to the Tasik villages with its tributaries	94812	
12	WB-12	The Zaget River with its tributaries	24807	
13	WB-13	The Ayriget headwaters to confluence with the Kishkosht River	23838	
14	WB-14	The Kishkosht River up to the Dastakert mine	3610	
15	WB-15	The Ayriget River, from Torunik village to the Tolors Reservoir	13857	
16	WB-16	The Loradzor River and its tributaries	48043	
17	WB-17	The Tatev River with its tributaries	31206	
18	WB-18	The Gorisget River up to the Brun village	24880	
19	WB-19	Tributaries of the Hagari River in the area of the RA	93325	
20	WB-20	The Qashun Rriver, from its headwaters to the David-Bek Reservoir	16115	
21	WB-21	The Qashun river, from the David-Bek Reservoir to the border of the RA	24484	
22	WB-22	Small tributaries of the Vorotan River south-east of the Qashun River basin	33238	
23	WB-23	The Sev Lich lake		1.85
24	WB-24	The Voghji River, up to confluence with the Ughtapan tributary, together with Kaputjugh, Kajaran and Ughtapan	30041	
25	WB-25	The Tsakkar River, with its Makanajur tributary, from the headwaters to the Zangezur Copper-Molybdenum mine	12581	
26	WB-26	The Pkhrut River	6882	
27	WB-27	The Dzagedzor River and its tributary	21968	
28	WB-28	The Geghi River, from the headwaters (Karahan and Ajabaj tributaries) to the Ajabaj settlement	23190	
29	WB-29	Right -bank tributary of the Geghi River, from headwaters to Copper-Molybdenum Combine settling ponds of the Ler-Ex LLC	5177	
30	WB-30	The Geghi River, from the Nor Astghaberd village to the Geghi Reservoir (Kyurut, Karachan and Sevashert tributaries)	61473	
31	WB-31	The Kard River	13543	
32	WB-32	The Geghi River, from the Geghi Reservoir to the confluence of the Voghji River with Sevkar tributary	14655	
33	WB-33	Left-bank Giratagh and Shgharshik tributaries of the Voghji River	15833	
34	WB-34	The Kavart River, from the headwaters to Kapan Copper-Molybdenum mine	1675	
35	WB-35	The Vachagan River, from the headwaters to the Kapan town	10045	
36	WB-36	The Geghanush River from the headwaters to the Geghanush tailing dam	23448	
37	WB-37	The Norashenik River, from the headwaters to the Achanan settlement	44666	
38	WB-38	The Artsvanik River, from headwaters to the Artsvanik tailing dam	20580	
39	WB-39	The Artsvanik River, from the Artsvanik tailing dam to the river mouth	2008	
40	WB-40	The Syunik River	15563	

#	Type	Name/ Location	Length, m	Area, km^2
41	WB-41	The Shikahogh River	32246	
42	WB-42	The Tsav River	65641	
43	WB-43	The Meghriget River, from headwaters to the Lichk village	9618	
44	WB-44	The Ayriget River	10880	
45	WB-45	The Gozgoz River, together with the Tashtun tributary	44753	
46	WB-46	The Kaler River	10454	
47	WB-47	The Mulk River and tributary to the south	13817	
48	WB-48	The Meghriget River, from confluence of the Gozgoz tributary and to the Tkhkut village	5450	
49	WB-49	The Boghakar River, from headwaters to the Karchevan canal	7418	
50	WB-50	The Boghakar River, from the Karchevan canal to the river mouth	7423	
51	WB-51	The Vardanidzor River	12223	
52	WB-52	The Meghriget River, right side Vahravar and Agarak tributaries	19391	
53	WB-53	Meghriget River, left side tributary in the Meghri town	20090	
54	WB-54	The Meghriget River, from the Meghri town to the river mouth	1663	
55	WB-55	The Karchevan River, from headwaters to the Karchevan village	4120	
56	WBR-01	The Vorotan River, in the Sisian town	3874	
57	WBR-02	The Vorotan River, downstream the Sisian town up to the Shamb Reservoir	13561	
58	WBR-03	The Vorotan River from the Shamb Reservoir to the border of the RA	33914	
59	WBR-04	The Tsghuk River form the Spandaryan Canal to Spandaryan Reservoir	4203	
60	WBR-05	The Shaqi River, downstream the Shaqi village (Shaqi Waterfall) and to the river mouth	1704	
61	WBR-06	The Sisian River, from the Tasik village to the Tolors Reservoir	2956	
62	WBR-07	The Sisian River, from the Tolors Reservoir to the river mouth	4360	
63	WBR-08	The Ayriget River, from the confluence point of the Kishkosht tributary to Torunik village and the Kishkosht tributary, from the Dastakert mine to the river mouth	7269	
64	WBR-09	The Gorisget River form the Brun village to the end of the Goris town	5272	
65	WBR-10	The Gorisget River form the Goris town to the border of the RA	11865	
66	WBR-11	The Voghji River from the confluence of the Ughtapan River to the Zangezur Copper-Molybdenum Combine of the Kajaran town	2542	
67	WBR-12	The Voghji River from the Zangezur Copper-Molybdenum Combine to the Voghji reclaimed tailing dam	7555	
68	WBR-13	The Voghji River from the Voghji reclaimed dam tailing to the Geghi River confluence	3890	
69	WBR-14	The Voghji River from confluence with Geghi River to Kapan town	5431	
70	WBR-15	The Voghji River in the Kapan town from the beginning of the town to confluence section with Kavart tributary	9949	
71	WBR-16	The Voghji River from confluence with Kavart tributary to the border of the Republic of Armenia	25639	
72	WBR-17	The Tsakkar River from confluence with Makanajur to the river mouth	3617	
73	WBR-18	The Darapi River with its tributaries up to Darazami tailing dam	4206	
74	WBR-19	The Right-bank tributary of the Geghi River, from the waste dumps of the Ler-Ex Copper-Molybdenum Combine to the river mouth, and the Geghi River from the confluence of the tributary to the Nor Astghaberd village	3187	
75	WBR-20	The Kavart River from the mine area of the Kapan Copper-Molybdenum Combine to the river mouth	3168	
76	WBR-21	The Vachagan River within the Kapan town	1705	
77	WBR-22	The Geghanush River from the Geghanush tailing dam to the river mouth	815	
78	WBR-23	The Norashenik River from wastewater pipeline of the Artsvanik tailing dam to the river mouth	5560	
79	WBR-24	The Meghriget River, from the Lichk village to the confluence of the Gozgoz tributary	4540	
80	WBR-25	The Meghriget River, between the Tkhkut and Vardanidzor communties	2556	

#	Type	Name/ Location	Length, m	Area, km^2
81	WBR-26	The Meghriget River, from the Vardanidzor village to the Meghri town	8116	
82	WBR-27	The Meghriget River, in the area of the Meghri town	3136	
83	WBR-28	The Karchevan River, from the Karchevan village to the Agarak Copper-Molybdenum Combine	1685	
84	WBR-29	The Karchevan River, from the Agarak Copper-Molybdenum Combine to the river mouth	4807	
85	WBR-30	The Khachidzor River, from the Agarak Copper-Molybdenum Combine waste dump to Darazami tailing dam	2998	
86	AWB-01	The Vorotan-Arpa-Sevan tunnel	6563	
87	AWB-02	The Spandaryan canal	43022	
88	AWB-03	The Derivation canal of Spandaryan HPP	9232	
89	AWB-04	The Derivation canal for diverting water from Angeghakot reservoir to Tolors reservoir	11016	
90	AWB-05	The Derivation canal of Shamb HPP	8905	
91	AWB-06	The Derivation canal of Tatev HPP	13578	
92	AWB-07	The Metsashen canal	10400	
93	AWB-08	The Karahunj reservoir's canal	7897	
94	AWB-09	The Main canal of Vorotan river	29109	
95	AWB-10	The flow diversion tunnel of the Artsvanik River	3647	
96	AWB-11	The Karchevan canal	10068	
97	HMWB-01	The Spandaryan Reservoir		11.31
98	HMWB-02	The Angeghakot Reservoir		0.39
99	HMWB-03	The Shamb Reservoir		0.95
100	HMWB-04	The Tolors Reservoir		2.92
101	HMWB-05	The Karahunj Reservoir		0.14
102	HMWB-06	The David-Bek Reservoir		0.31
103	HMWB-07	The Geghi Reservoir		0.25
104	HMWB-08	The Pkhrut reclaimed tailing dam		0.11
105	HMWB-09	The Darazami reclaimed tailing dam		0.09
106	HMWB-10	The Voghji reclaimed tailing dam		0.66
107	HMWB-11	The settling ponds of the Ler-Ex Copper-Molybdenum Combine		0.02
108	HMWB-12	The Geghanush tailing dam		0.29
109	HMWB-13	The Artsvanik tailing dam		3.99
110	HMWB-14	The Darazami tailing dam		0.96

Annex E. Descriptpin of Groundwater Bodies in the Southern BMA

Vorotan River Basin

GWB G01: The GWB occupies the left and a small extent of the right bank of the Vorotan catchment. It is represented by Quaternary fractured andesite, andesite-basalt and basalt lava flows and their clastolites. The related groundwater in the upper and middle reaches of the Vorotan River discharge as high-flow springs – Gorayk, Sarnakunk, Spandaryan, Angeghakot, Shaki, Vaghatin, and Vorotan, at altitudes of 1700-2000 m. The total mineralization is up to 200 mg/l, and water temperature is in the range of - 7-9^0C.

The concavities midstream the Vorotan River are located at altitudes of 1660-2120 m and represent a series of smaller concavities - Gorayk, Spandaryan, Sarnakunk, Angeghakot, Shaki, Sisian and Shamb. They are surrounded by Quaternary andesite-basalt lavas and comprise of the alternation of fluvial-lacustrine sand-boulder deposits and extensive water-repellent clay layers.

Two confined aquifers are observed within concavities; the first is located at a depth of 22-180 m, and the second –70-288 m. The aquifers are 8-50 m and 4-180 m thick, respectively. The upper aquifer in Gorayk, Angeghakot, and Shamb concavities lies at a depth of 13, 20-80 and 60 m, respectively. These aquifers are confined, and the yield of the self-flowing well is in the range of 0.3-4 l/sec.

Five confined aquifers were identified with wells in Sisian and Shamb concavities. The lower aquifer waters are mineralized, which is explained by the presence of a deep rupture that passes in the direction of the Vorotan River and serves as a passage for penetration of carbon dioxide. The main anthropogenic pressures are from cattle breeding, municipal/household wastewater, and discharge water from irrigated lands. As of 01 January 2014, the anthropogenic pressures were not significant.

Parameter	Water Body in volcanic rocks
GWB code	G01
GWB name	Syunik thick lava stratum
GWB Unit Area, km^2	8089.03
Stratigraphy, geological index	Q_{1-3}- N_2^3
Lithological composition	Andesite-basalt huge lava flows; in concavities – conglomerates, slightly cemented sandstones, and alternation of lacustrine diatomite clays and pumice and ash formations.
Aquifer type: unconfined or confined	Unconfined and confined
Spring or well	Springs and wells
Number of aquifers	1-5
Overlying strata	Waterless avalanche rocks
GWB thickness, Min, Max, Mean	10-100 m
Hydraulic conductivity К, m/day	15-50
Used for abstraction >10 m^3/day: yes/no	Yes
Purpose of abstraction	Drinking, agricultural and industrial water supply
Yield of wells/springs, l/sec	80-1500
Chemical composition (main cations and anions)	Hydrocarbonate-calcium HCO_3^- ,Ca^{2+}, Mg^{2+}
Main recharge source	Atmospheric precipitation
Prevailing anthropogenic pressure(s)	Cattle breeding, municipal/household wastewater, irrigation
GWB chemical status	good
GWB quantitative status	good
Reliability of information	Satisfactory
Annual precipitation, mm	500-800

GWB G02: The GWB is located in the Gorisget catchment, left-wing tributary of the Vorotan River. Akner and other low-flow springs (cumulative yield of up to 120 l/sec) serve as a source of water supply to Goris region.

Goris stratum is represented by large fragments of tuff-breccia and andesite-basalt lava substrata. The main anthropogenic pressures are from cattle breeding and irrigation. As of 01 January 2014, the anthropogenic pressures were not significant.

Parameters	**Water body in volcanic tuff-lava, or Goris strata group**
GWB code	G02
GWB name	Gorisget basin
GWB Unit Area, km^2	138.35
Geological index	N_1
Lithological composition	Pumice tuff, tuff-lava, tuff-breccia, with andesite-basalt lava substrata
Aquifer type: unconfined or confined	Unconfined
Spring or well	Springs
Overlying strata	Tufogenic rocks of the same composition, and overlaying alluvial-diluvial deposits
GWB thickness, m	10-60 m
Hydraulic conductivity K, m/day	0.5-6
Used for abstraction >10 m^3/day: yes/no	Yes
Purpose of abstraction	Drinking water supply
Yield of springs, l/sec	120 l/sec, related to andesite lava substrata
Chemical composition (main cations and anions)	Hydrocarbonate-calcium HCO_3^- ,Ca^{2+}, Mg^{2+}
Main recharge source	Atmospheric precipitation
Prevailing anthropogenic pressure(s)	Cattle breeding, irrigation
GWB chemical status	Satisfactory
GWB quantitative status	Satisfactory
Reliability of information	Low
Annual precipitation, mm	600

GWB G03: The GWB occupies Dastakert-Darbas area lying midstream and downstream the right bank of the Vorotan River. Groundwater is generated and circulated in the upper weathering crust of volcanogenic-sedimentary rocks, and fracturing occurs lightly in the underlying rock matrix. The fragmented terrain does not allow for formation of extensive aquifers and contributes to distribution of groundwater in different directions. The springs have a yield of up to 1 l/sec, and water temperature is in the range of 8-12^{0}C. The main anthropogenic pressures are from cattle breeding and irrigation. As of 01 January 2014, the anthropogenic pressures were not significant.

Parameters	**Water body in volcanogenic-sedimentary and intrusive rocks**
GWB code	G03
GWB name	Dastakert-Darbas area Midstream and downstream the right bank of the Vorotan River
GWB Unit Area, km^2	691.65
Geological index	P-₽$_2$
Lithological composition	Tuff-breccia, tuff-sandstone, tuff-conglomerate, granodiorite, monzonite, and their other varieties
Aquifer type: unconfined or confined	Unconfined
Spring or well	Springs
Overlying strata	Eluvial-diluvial deposits
GWB thickness, m	1-10 m
Used for abstraction >10 m^3/day: yes/no	Yes
Purpose of abstraction	Drinking, irrigation and other economic purposes

Yield of wells and springs, l/sec	1-6
Chemical composition (main cations and anions)	Hydrocarbonate-calcium HCO_3^- ,Ca^{2+}, Mg^{2+}
Main recharge source	Atmospheric precipitation
Prevailing anthropogenic pressure(s)	Cattle breeding, irrigation
GWB chemical status	Satisfactory
GWB quantitative status	Satisfactory
Reliability of information	Low
Annual precipitation, mm	600

GWB G04: The GWB occupies Shinuhayr-Tatev area on the right bank of the Vorotan River. Water-bearing rocks are mainly represented by limestones, lime sandstones and marlstones. There is a continuous alternation of limestones and sandstones. Around 60 springs are related to the mentioned water-bearing complex in the Vorotan basin, with a cumulative yield of 390l/sec. Groundwater related to this complex are hydrocarbonate, and mineralization is in the range of 0,4-0,8 g/l. The main anthropogenic pressures are from cattle breeding and irrigation. As of 01 January 2014, the anthropogenic pressures were not significant.

Parameters	Water body in carbonate rocks
GWB code	G04
GWB name	Shinuhayr-Tatev area
GWB Unit Area, km^2	137.55
Geological index	K
Lithological composition	Limestones, lime sandstones and marlstones
Aquifer type: unconfined or confined	Unconfined
Spring or well	Springs
Overlying strata	Limestones
GWB thickness, m	5-10
Used for abstraction >10 m3/day: yes/no	Yes
Purpose of abstraction	Agricultural
Yield of springs, l/sec	1-6
Chemical composition (main cations and anions)	Hydrocarbonate-calcium HCO_3^- ,Ca^{2+}, Mg^{2+}
Main recharge source	Atmospheric precipitation
Prevailing anthropogenic pressure(s)	Cattle breeding, irrigation
GWB chemical status	Satisfactory
GWB quantitative status	Satisfactory
Reliabilityof information	Low
Annual precipitation, mm	600

Voghji River Basin

GWB G05: The GWB occupies the catchment of the Shikadzor (Ajabaj), upstream tributary of the Geghi River. Groundwater distribution is of local character.

The relatively high-flow springs are located along Debakli and Khustup-Giratagh deep faults. The yield of individual springs is in the range of 5-6 l/sec. They are located at altitudes of 2000-2100 m. The main anthropogenic pressures are from cattle breeding, drinking/domestic water use, mining, and discharge water from irrigated lands. As of 01 January 2014, the anthropogenic pressures were not significant.

Parameters	Water body in volcanogenic-sedimentary and transforming rocks
GWB code	G05

Parameters	Water body in volcanogenic-sedimentary and transforming rocks
GWB name	Shikadzor
GWB Unit Area, km^2	25.08
Geological index	D
Lithological composition	Tufogenic rocks, porphyrites, slates
Aquifer type: unconfined or confined	Unconfined
Spring or well	Springs
Number of aquifers	1
Overlying strata	Eluvial-dealluvial deposits
GWB thickness, m	10-15 m
Hydraulic conductivity K, m/day	-
Used for abstraction >10 m^3/day: yes/no	Yes
Number of operated wells	-
Purpose of abstraction	Drinking, agricultural and industrial water supply
Yield of springs, l/sec	200
Chemical composition (main cations and anions)	Hydrocarbonate-calcium HCO_3^- ,Ca^{2+}, Mg^{2+}
Main recharge source	Atmospheric precipitation
Prevailing anthropogenic pressure(s)	Cattle breeding, drinking/domestic water use, mining, irrigation
GWB chemical status	Good
GWB quantitative status	Good
Reliability of information	Satisfactory
Annual precipitation, mm	700

GWB G06: The GWB occupies the left-wing midstream area of the Geghi River Basin. The springs are located at an altitude of about 1500 m, and total mineralization is 0.38 g/sec. Groundwater is generated in the fractures of limestones and intrusive rocks. A confined aquifer, with a yield of 0.8 l/sec, was identified at a depth 31-111 m in fractured granites in the vicinity of Getishen village. The main anthropogenic pressures are from drinking/domestic water use, cattle breeding, and irrigation. As of 01 January 2014, the anthropogenic pressures were not significant.

Parameters	Water body in limestones and intrusive rocks in the Geghi River Basin
GWB code	G06
GWB name	Geghi
GWB Unit Area, km^2	6.73
Geological index	D-S
Lithological composition	Limestones, intrusive rocks
Aquifer type: unconfined or confined	Unconfined
Spring or well	Springs and wells
Number of aquifers	1
Overlying strata	Eluvial-diluvial deposits
GWB thickness, m	< 10 m
Hydraulic conductivity K, m/day	-
Used for abstraction >10 m3/day: yes/no	Yes
Number of operated wells	-
Purpose of abstraction	Drinking, agricultural and industrial water supply
Yield of springs, l/sec	50
Chemical composition (main cations and anions)	Hydrocarbonate-calcium HCO_3^- ,Ca^{2+}, Mg^{2+}
Main recharge source	Atmospheric precipitation
Prevailing anthropogenic pressure(s)	Drinking/domestic water use, cattle breeding, irrigation
GWB chemical status	Good
GWB quantitative status	Good
Reliability of information	Satisfactory
Annual precipitation, mm	600

GWB G07: The GWB is located at altitudes of about 1600 - 1800 m in the lower section of the Gyard, right-wing tributary of the Geghi River. Total mineralization of water is 0.3 g/l. The main anthropogenic pressures are from drinking/domestic water use, mining, and cattle breeding. As of 01 January 2014, the anthropogenic pressures were not significant.

Parameters	Water body in limestones and mostly tufogenic rocks of the Gyard, right-wing tributary of the Geghi River
GWB code	G07
GWB name	Gyard
GWB Unit Area, km^2	4.9
Geological index	D
Lithological composition	Tufogenic and carbonate rocks
Aquifer type: unconfined or confined	Unconfined
Spring or well	Springs
Number of aquifers	1
Overlying strata	Eluvial deposits
GWB thickness, m	10 m
Used for abstraction >10 m3/day: yes/no	Yes
Purpose of abstraction	Drinking, agricultural and industrial water uses
Yield of springs, l/sec	150
Chemical composition (main cations and anions)	Hydrocarbonate-calcium HCO_3^- ,Ca^{2+}, Mg^{2+}
Main recharge source	Atmospheric precipitation
Prevailing anthropogenic pressure(s)	Cattle breeding, drinking/domestic water use, mining
GWB chemical status	Good
GWB quantitative status	Good
Reliability of information	Satisfactory
Annual precipitation, mm	600

GWB G08: The GWB is located at an altitude of 1700 m in Verin Giratagh community and it is used through the captages of Surin Kap(4) and Jrakhor (1) springs. The prevailing anthropogenic pressures include the discharge water from irrigated lands, and cattle breeding. As of 01 January 2014, the anthropogenic pressures were not significant.

Parameters	Water body in carbonate rocks
GWB code	G08
GWB name	Surin Kap and Jrakhor
GWB Unit Area, km^2	4.04
Geological index	J
Lithological composition	Limestones, dolomites
Aquifer type: unconfined or confined	Unconfined
Spring or well	Springs
Number of aquifers	1
Overlying strata	Eluvial deposits
GWB thickness, m	< 10 m
Used for abstraction >10 m3/day: yes/no	Yes
Purpose of abstraction	Drinking/domestic water use
Yield of springs, l/sec	32
Chemical composition (main cations and anions)	Hydrocarbonate-calcium HCO_3^- ,Ca^{2+}, Mg^{2+}
Main recharge source	Atmospheric precipitation
Prevailing anthropogenic pressure(s)	Cattle breeding, irrigation
GWB chemical status	Good
GWB quantitative status	Good
Reliability of information	Satisfactory
Annual precipitation, mm	600

GWB G09: The GWB represents a river water intake for drainage water. It is located at an altitude of 1325 m in the river head of Chanakhchi tributary of the Voghji River. The main anthropogenic pressure is from cattle breeding. As of 01 January 2014, the anthropogenic pressure was not significant.

Parameters	Water body in tufogenic rocks
GWB code	G09
GWB name	Chanakhchi
GWB Unit Area, km^2	4.96
Geological index	J
Lithological composition	Tufogenic rocks
Aquifer type: unconfined or confined	Unconfined
Spring or well	Springs
Number of aquifers	1
Overlying strata	Eluvial deposits
GWB thickness, m	<10 m
Used for abstraction >10 m3/day: yes/no	Yes
Purpose of abstraction	Drinking/domestic water use
Yield of springs, l/sec	60
Chemical composition (main cations and anions)	Hydrocarbonate-calcium HCO_3^- ,Ca^{2+}, Mg^{2+}
Main recharge source	Atmospheric precipitation
Prevailing anthropogenic pressure	Cattle breeding
GWB chemical status	Good
GWB quantitative status	Good
Reliability of information	Satisfactory
Annual precipitation, mm	600

GWB G10: The GWB occupies Kapan town with adjacent areas – Jrakhor, Vachagan, Halidzor springs, with a yield of 14 l/sec. It also covers the aquifers in the Voghji River Valley, represented by riverine, volcanogenic-sedimentary and intrusive rocks. The anthropogenic pressures include irrigation, Shahumyan Gold Mine, Geghanush tailing dump, as well as municipal/household wastewater from Kapan town. As of 01 January 2014, the anthropogenic pressures were not significant.

Parameters	Water body in tufogenic rocks
GWB code	G10
GWB name	Kapan
GWB Unit Area, km^2	23,79
Geological index	J
Lithological composition	Tufogenic rocks
Aquifer type: unconfined or confined	Unconfined
Spring or well	Springs and wells
Number of aquifers	1
Overlying strata	Eluvial deposits
GWB thickness, m	20-80 m
Used for abstraction >10 m3/day: yes/no	Yes
Purpose of abstraction	Drinking/domestic water use
Yield of springs, l/sec	60
Chemical composition (main cations and anions)	Hydrocarbonate-calcium HCO_3^- ,Ca^{2+}, Mg^{2+}
Main recharge source	Atmospheric precipitation, infiltration from the Voghji riverbed
Prevailing anthropogenic pressure(s)	Irrigation, mining, municipal/household wastewater
GWB chemical status	Satisfactory
GWB quantitative status	Satisfactory
Reliability of information	Satisfactory
Annual precipitation, mm	600

Meghriget River Basin

GWB G11: The GWB is located in Vank-Kaler area. It relates to upland springs with a highly fluctuating flow rate of 0.1-5 l/sec and mineralization of 0.5 g/l, and lowland fractured aquifers (in intrusive rocks)with a positive water pressure. The springs are located at altitudes of 1900-2500 m. The aquifers have good natural protection. The main anthropogenic pressures are from drinking/domestic water use, and cattle breeding. As of 01 January 2014, the anthropogenic pressures were not significant.

Parameters	Water body in eluvial/dealluvial and fractured intrusive rocks
GWB code	G11
GWB name	Kaler-Vank area
GWB Unit Area, km^2	5.37
Geological index	Q_2
Lithological composition	Eluvial-diluvial soft fragmental deposits, fractured monzonites and diorites
Aquifer type: unconfined or confined	Unconfined and confined
Spring or well	Springs and wells
Number of aquifers	1
Overlying strata	Eluvial-diluvial deposits
GWB thickness, m	5-40 m
Hydraulic conductivity K, m/day	5-25
Used for abstraction >10 m^3/day: yes/no	Yes
Purpose of abstraction	Drinking and agricultural water supply
Yield of individual springs, l/sec	5
Chemical composition (main cations and anions)	Hydrocarbonate-calcium HCO_3^-,Ca^{2+}, Mg^{2+}
Main recharge source	Atmospheric precipitation
Prevailing anthropogenic pressure(s)	Cattle breeding, drinking/domestic water use
GWB chemical status	Good
GWB quantitative status	Good
Reliability of information	Satisfactory
Annual precipitation, mm	700-800

GWB G12: The GWB is located 3.4 km northwest of Lichk village, at altitudes of 2350-2500 m. It represents a group of springs with a cumulative yield of 28 l/sec and total mineralization of 0.2 g/sec. Cattle breeding is the prevailing anthropogenic pressure. As of 01 January 2014, the anthropogenic pressure was not significant.

Parameters	Water body in tectonic fault zone
GWB code	G12
GWB name	Lichk area
GWB Unit Area, km^2	4.87
Geological index	Q_2-PZ
Lithological composition	Contact zone of intrusive bodies and altered Paleozoic rocks, weathering fractures of intrusive bodies
Aquifer type: unconfined or confined	Unconfined
Spring or well	Springs
Number of aquifers	1
Overlying strata	Diluvial deposits, weathered granodiorites
GWB thickness, m	<10 m
Used for abstraction >10 m^3/day: yes/no	Yes
Purpose of abstraction	Drinking/domestic water supply
Yield of springs, l/sec	28
Chemical composition (main cations and anions)	Hydrocarbonate-calcium HCO_3^-,Ca^{2+}, Mg^{2+}

Main recharge source	Atmospheric precipitation
Prevailing anthropogenic pressure(s)	Cattle breeding
GWB chemical status	Good
GWB quantitative status	Good
Reliability of information	Satisfactory
Annual precipitation, mm	700-800

GWB G13: The GWB is located 2.5 km northwest of Tashtun village, at altitudes of 2200-2400 m. It represents a group of springs with a cumulative yield of 36 l/sec and total mineralization of 0.3 g/l. Cattle breeding is the prevailing anthropogenic pressure. As of 01 January 2014, the anthropogenic pressure was not significant.

Parameters	Water body in tectonic fault zone
GWB code	G13
GWB name	Tashtun area
GWB Unit Area, km^2	5.31
Geological index	Q_2-PZ
Lithological composition	Contact zone of intrusive bodies and altered Paleozoic rocks, weathering fractures of intrusive bodies
Aquifer type: unconfined or confined	Unconfined
Spring or well	Springs
Number of aquifers	1
Overlying strata	Diluvial deposits, weathered granodiorites
GWB thickness, m	<10 մ
Used for abstraction >10 m^3/day: yes/no	Yes
Purpose of abstraction	Drinking/domestic water supply
Yield of springs, l/sec	36
Chemical composition (main cations and anions)	Hydrocarbonate-calcium HCO_3^-,Ca^{2+}, Mg^{2+}
Main recharge source	Atmospheric precipitation
Prevailing anthropogenic pressure(s)	Cattle breeding
GWB chemical status	Good
GWB quantitative status	Good
Reliability of information	Satisfactory
Annual precipitation, mm	700-800

GWB G14: The GWB covers the neighboring areas of Lehvaz-Meghri settlements. The uplands are represented by fractured intrusive rocks and lowlands by riverine deposits. The springs with a flow rate of 0.1-1 l/sec and mineralization of 0.2-0.6 g/l are related to fractured intrusive rocks. A confined aquifer with a flow rate of 1.5 l/sec was identified at a depth of 87-92 m in fractured diorites in Meghri. An unconfined aquifer was identified at a depth of 1.5-40 m in riverine deposits on the left bank of the Meghriget River in Lehvaz village. These waters have poor natural protection. The main anthropogenic pressures are from irrigation, municipal/domestic wastewater and cattle breeding. As of 01 January 2014, the anthropogenic pressures were not significant.

Parameters	Water body in riverine and intrusive rocks
GWB code	G14
GWB name	Lehvaz-Meghri area
GWB Unit Area, km^2	11.62
Geological index	Q_2
Lithological composition	Intrusive rocks – granodiorite, gabbroid, syenite, monzonite; riverine deposits – boulder, gravel, sand.
Aquifer type: unconfined or confined	Unconfined and confined
Spring or well	Springs and wells
Number of aquifers	1
Overlying strata	Riverine deposits and intrusive rocks

Parameters	Water body in riverine and intrusive rocks
GWB thickness, m	10-40 m
Used for abstraction >10 m^3/day: yes/no	Yes
Purpose of abstraction	Drinking/domestic water supply
Yield of springs, l/sec	16
Chemical composition (main cations and anions)	Hydrocarbonate-calcium HCO_3^-,Ca^{2+}, Mg^{2+}
Main recharge source	Atmospheric precipitation
Prevailing anthropogenic pressure(s)	Irrigation, cattle breeding, municipal wastewater
GWB chemical status	Good
GWB quantitative status	Good
Reliability of information	Satisfactory
Annual precipitation, mm	500-600

GWB G15: The GWB embraces the lower reaches of the Karchevan River, the neighboring areas of Agarak town. The yield of springs is 0.1-1 l/sec, and mineralization - 0.2-0.6 g/sec. One unconfined aquifer was identified at a depth of 13-21 m in boulder-gravel-sand rocks in Agarak. It has poor natural protection. The main anthropogenic pressures are from municipal/domestic wastewater and mining. As of 01 January 2014, the anthropogenic pressures were not significant.

Parameters	Water body in intrusive rocks
GWB code	G15
GWB name	Agarak
GWB Unit Area, km^2	2.4
Geological index	Q_2
Lithological composition	Intrusive rocks – granodiorite, gabbroid, syenites, monzonite; riverine deposits – boulder, gravel, sand.
Aquifer type: unconfined or confined	Unconfined
Spring or well	Springs and wells
Number of aquifers	1
Overlying strata	Riverine deposits
GWB thickness, m	35-40 m
Used for abstraction >10 m^3/day: yes/no	Yes
Purpose of abstraction	Drinking/domestic water supply
Yield of springs, l/sec	15
Chemical composition (main cations and anions)	Hydrocarbonate-calcium HCO_3^-,Ca^{2+}, Mg^{2+}
Main recharge source	Atmospheric precipitation
Prevailing anthropogenic pressure(s)	Mining industry, Municipal wastewater
GWB chemical status	Satisfactory
GWB quantitative status	Satisfactory
Reliability of information	Satisfactory
Annual precipitation, mm	500-600

GWB G16: The GWB occupies the neighboring area of Alvank village. The riverine deposits are 40 m thick, and groundwater is abstracted through kyahrizes. The main anthropogenic pressures are from irrigation, municipal/household wastewater, and cattle breeding. As of 01 January 2014, the anthropogenic pressures were not significant.

Parameters	Water body in riverine deposits
GWB code	G16
GWB name	Alvank area
GWB Unit Area, km^2	1.25
Geological index	Q
Lithological composition	Riverine deposits - boulder, gravel, sand
Aquifer type: unconfined or confined	Unconfined

Spring or well	Kyahrizes and wells
Number of aquifers	1
Overlying strata	Riverine deposits
GWB thickness, m	5-20 m
Used for abstraction >10 m^3/day: yes/no	Yes
Purpose of abstraction	Drinking/domestic water supply
Yield of springs, l/sec	1-5
Chemical composition (main cations and anions)	Hydrocarbonate-calcium HCO_3^- ,Ca^{2+}, Mg^{2+}
Main recharge source	Surface flow
Prevailing anthropogenic pressure(s)	Cattle breeding, municipal/household wastewater and discharge water from irrigated lands
GWB chemical status	Satisfactory
GWB quantitative status	Satisfactory
Reliability of information	Satisfactory

GWB G17: The GWB occupies the neighboring area of Shvanidzor village, lying at an altitude of about 650 m. The riverine deposits are 40 m thick, and groundwater is abstracted through kyahrizes. The main anthropogenic pressures are from irrigation, municipal/household wastewater, and cattle breeding. As of 01 January 2014, the anthropogenic pressures were not significant.

Parameters	Water body in riverine deposits
GWB code	G17
GWB name	Shvanidzor area
GWB Unit Area, km^2	1.2
Geological index	Q
Lithological composition	Riverine deposits – boulder, gravel, sand
Aquifer type: unconfined or confined	Unconfined
Spring or well	Kyahrizes and wells
Number of aquifers	1
Overlying strata	Riverine deposits
GWB thickness, m	5-20 m
Used for abstraction >10 m^3/day: yes/no	Yes
Purpose of abstraction	Drinking/household water supply
Yield of kyahrizes, l/sec	4
Chemical composition (main cations and anions)	Hydrocarbonate-calcium HCO_3^- ,Ca^{2+}, Mg^{2+}
Main recharge source	Surface flow
Prevailing anthropogenic pressure(s)	Irrigation, municipal/household wastewater, and cattle breeding
GWB chemical status	Satisfactory
GWB quantitative status	Satisfactory
Reliability of information	Satisfactory

GWB G18: The GWB lies at an altitude of 600 m and occupies the neighboring area of Nrnadzor village. Riverine deposits are 40 m thick, and groundwater is abstracted through kyahrizes. The main anthropogenic pressures are from irrigation, municipal-household wastewater, and cattle breeding. As of 01 January 2014, the anthropogenic pressures were not significant.

Parameters	Water body in riverine deposits
GWB code	G18
GWB name	Nrnadzor area
GWB Unit Area, km^2	3.68
Geological index	Q
Lithological composition	Riverine deposits –boulder, gravel, sand
Aquifer type: unconfined or confined	Unconfined
Spring or well	Kyahrizes and wells

Number of aquifers	1
Overlying strata	Riverine deposits
GWB thickness, m	5-20 m
Used for abstraction >10 m^3/day: yes/no	Yes
Purpose of abstraction	Drinking/household water supply
Yield of kyahrizes, l/sec	1.4
Chemical composition (main cations and anions)	Hydrocarbonate-calcium HCO_3^- ,Ca^{2+}, Mg^{2+}
Main recharge source	Surface flow
Prevailing anthropogenic pressure(s)	Irrigation, municipal/household wastewater, and cattle breeding
GWB chemical status	Satisfactory
GWB quantitative status	Satisfactory
Reliability of information	Satisfactory

GWB G19: The GWB is represented by riverine deposits and highly fractured gabbro-diorite intrusive rocks. The flow of the springs is highly fluctuating, being in the range of 0.1-1 l/sec. Confined aquifers were identified in the western(at a depth of 117-130 m) and eastern (at a depth of 125-135 m)parts of Vahravar village, with flow rates of 0.1 and 0.3 l/sec, respectively. A confined aquifer was identified at a depth of 85-95 m in fractured granodiorites in the northern part of Kuris village, the water table of which was restored at a depth of 24 m. Another confined aquifer with a flow rate of 0,3 l/sec was identified at a depth of 125-133 m in fractured monzonites in the northeastern part of Vardanidzor village. The GWB is exposed to anthropogenic pressures, particularly irrigation, and municipal/household wastewater. As of 01 January 2014, the anthropogenic pressures were not significant.

Parameters	Water body in intrusive rocks
GWB code	G19
GWB name	Vardanidzor-Vahravar-Kuris areas
GWB Unit Area, km^2	12.9
Geological index	Q
Lithological composition	Riverine deposits – boulder, gravel, sand
Aquifer type: unconfined or confined	Unconfined and confined
Spring or well	Springs and wells
Number of aquifers	1
Overlying strata	Eluvial deposits
GWB thickness, m	8-15 m
Used for abstraction >10 m^3/day: yes/no	Yes
Purpose of abstraction	Drinking/domestic water supply
Yield of springs, l/sec	1,4
Chemical composition (main cations and anions)	Hydrocarbonate-calcium HCO_3^- ,Ca^{2+}, Mg^{2+}
Main recharge source	Surface flow
Prevailing anthropogenic pressure(s)	Irrigation, municipal/household wastewater
GWB chemical status	Satisfactory
GWB quantitative status	Satisfactory
Reliability of information	Satisfactory

Annex F. List of Hydrochemical Parameters of Surface Water Resources

Temperature regime

1. Water temperature

Oxygen regime

2. Dissolved oxygen, Saturation of dissolved oxygen
3. Biochemical oxygen demand (5 days)
4. Chemical oxygen demand, Mn-oxidation method
5. Chemical oxygen demand, Cr-oxidation method

Biogenic elements

6. Total inorganic azote
7. Nitrate ion
8. Nitrite ion
9. Ammonium ion
10. Total Phosphorus
11. Orthophosphate ion
12. Total organic azote
13. Total organic carbon

Mineralization

14. Chloride ion
15. Sulfate ion
16. Silicate
17. Total Mineralization
18. Conductivity

Acidic conditions

19. pH
20. Total Hardness

Other parameters

21. Floating particles
22. Suspended Solids
23. Odor (20°C and 60°C)
24. Color
25. Transparency

Metals

26. Cadmium
27. Lead
28. Mercury
29. Nickel
30. Copper
31. Zinc
32. Chromium
33. Arsenic
34. Molybdenum
35. Manganese
36. Vanadium
37. Cobalt
38. Iron
39. Calcium
40. Magnesium
41. Barium
42. Beryllium
43. Potassium
44. Sodium
45. Lithium
46. Boron
47. Aluminum, total
48. Selenium, total
49. Antimony, total
50. Tin, total

EU WFD Primary Polutants List

51. Alachlor
52. Anthracene
53. Atrazine
54. Benzene
55. Pentabromophenyl ether
56. C 10-13-chloroalkane
57. Chlorfenvinphos
58. Chlorpyrifos
59. 1,2-dichloroethane
60. Dichloromethan
61. Di (2-ethylhexyl) phthalate
62. Diuron
63. Endosulfan
64. Fluoranthene
65. Hexachlorobenzene
66. Hexachlor-butadiene
67. Hexachlorocyclohexane
68. Isoproturon
69. Naphthalene
70. Nonylphenol
71. Octylphenol
72. Pentachlorobenzene
73. Pentachlorofenol
74. Benzo-α-pyrene
75. Benzo-b-fluoranthene
76. Benzo-perylene
77. Bezno-c-fluoranthene)
78. Indeno(1 2 3-cd)pyrene
79. Simazine
80. Tributyltin substances
81. Trichlorobenzene(all isomers)
82. Trichloromethane(chloroform)

83. Triptorelin
84. DDT
85. Para-para-DDT
86. Aldrin
87. Dieldrin
88. Endrin
89. Isodrin
90. Carbon tetrachloride
91. Tetrachloroethylene
92. Trichloroethylene

Radioactivity

93. Gamma-activity
94. Betta-activity

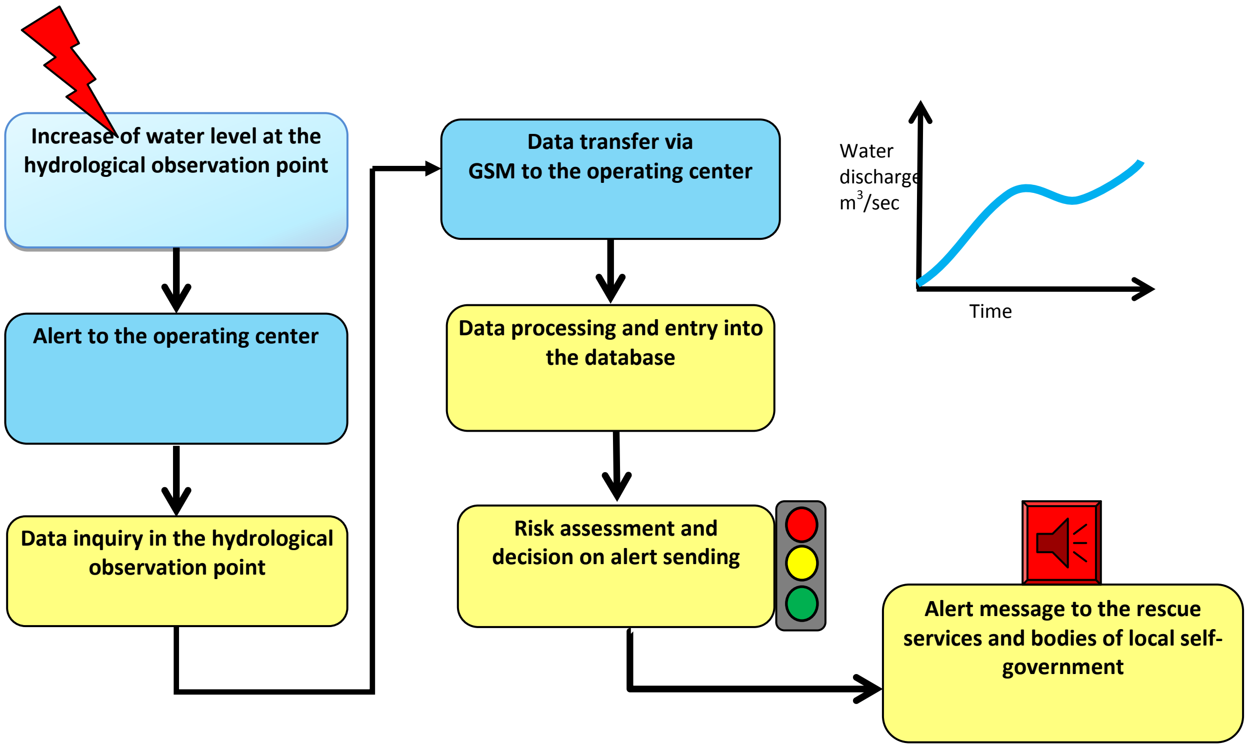
Special pollutants

95. Heptachlor
96. Polychlorinated biphenyls
97. Chlorine-organic pollutants
98. Surface active anionic substances
99. Non-ionic surface substances
100. Phenols
101. *Oil products

Annex G: Structural Design of the Floods Warning Center in the Southern BMA

According to the UN's disaster reduction strategy the monitoring services, based on data on risks, are targeted at determining short-term changes of hazards, vulnerability of areas, predicting possible long-term changes, revision and updating of the maps and data on disaster risks in the river basins, regularly developing risks and vulnerability indicator system in the river basins, implementing monitoring and adjusting data on frequency of floods and mudflows.

It is necessary to establish Floods Warning Center in the river basisns, with the below presented structural scheme of warning.



Structural scheme of the floods warning

Annex H. Questionnaire

IDENTIFICATION OF PRESSURES ON WATER RESOURCRES OF THE RIVER BASIN

I. GENERAL INFORMATION

Name ____

Community ____

Organization ____

II. STATUS OF WATER SECTOR IN THE RIVER BASIN

A. Water relater disasters

A1. Indicate water related disasters present in the river basin

□ Floods □ Mudflows □ Snow melt □ No □ Other

A2. Indicate main types of damages caused by water related disasters

□ Infrastructure □ Arable lands □ Homestead land plots □ Livestock
□ No damage □ Other

A3. Propose measures to mitigate the above mentioned disasters

□ Regulation of river flow □ Flood protection structures
□ Development of drainage system □ Other

B. Water use

B1. Indicate level of water use efficiency in the river basins

□ Efficient □ Mostly efficient □ Not efficient □ Highly inefficient □ Hard to answer

B2. Proposed approaches for effective water use

□ Water meters □ Water saving technologies
□ Regulation of river flow, i.e. reservoirs construction □ Other

B3. Classify water use priorities (use scale I-VII for classification)

Drinking-household _______	Recreation _______	Hydropower generation ______
Hydrological reserve ______	Irrigation _______	Industry ______
Fish farming _______	Other _______	

C. Water quantity

Drinking water

C1. Is quantity of drinking water sufficient?

□ Yes □ Partially □ No □ Hard to answer

Irrigation water

Is quantity of irrigation water sufficient?

□ Yes □ Partially □ No □ Hard to answer

D. Water Quality

D1. Is quality of drinking water is sufficient

□ Yes, always □ Mainly Yes □ Not always □ No □ Hard to answer

D2. Indicate the main source of pollution of water resources

□ Land cultivation □ Livestock production □ Solid wastes □ Industrial wastes □ Wastewaters
□ Other ____

E. Water Resources Management and Public Participation

E1. Indicate the sector (one sector only), which requires focus of the water resources management agency

□ Water quality □ Water quantity □ Promotion of effective water use □ River flow regulation
□ Mitigation of water related disasters □ Water resources protection
□ Water use compliance assurance □ Other ___________

E2. Is there a need for more frequent involvement of public in decision-making process on water resources management?

□ Yes □ No □ Hard to answer

E3. Proposed mechanisms for public involvement in resolution of water management issues

□ Establishment of a Basin Public Council
□ Public hearings on important water sector related issues
□ Other __________________________

F. Additional comments on the topic ____

Annex I. Approaches for forecasting the economic development and water use

Approaches for forecasting the economic development and water use in the river basins of the Southern BMA are following:

Water use sector	Basis for the forecast
Hydpropower generation	Forecasts were made based on licenses issued by the RA Public Services Regulatory Condition for construction of new SHPPs. Based on the licenses, additional capacity for each year was forecasted
Fish farming	Forecasts were made based on the number of entities in the sector and average water demand
Irrigation	Forecasts were made based on the planned extension of arable lands and water demand as it is defined in the sector development strategy
Mining industry	Forecasts were made on the planned volumes of ore extraction by three largest companies
Other industry	Forecasts were made based on the number of entities in the sector and average water demand
Drinking-household	Forecasts were made based on projected population growth and with application of normative water demand
Livestock watering	Forecasts were made on projected increase of the livestock and with application of normative water demand

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